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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an information processing equipment, and more particularly to an information processing apparatus suitable for a tamper resistance device such as an IC card providing high security.

[0002] An IC card is mainly used for storing information in a manner so as not to be altered by a third party or for enciphering data or deciphering a cipher text by using a cipher key which is kept in secret. Since the IC card is not provided with a power source, it becomes operable only when it is inserted into a reader-writer. The IC card receives a command from the reader-writer to execute data transfer.

[0003] As shown in Fig. 1, an IC card has the structure that an IC card chip 102 is fabricated on a card 101. A general IC card has contacts via which a power is supplied from a reader-writer and data is transferred.

[0004] The structure of an IC card chip is basically the same as that of a microcomputer. As shown in Fig. 2, the IC card chip includes a central processor 201, a storage memory 204, an input/output port 207, and a co-processor 202. The central processor 201 executes logical and arithmetic calculations, and the storage memory 204 stores programs and data. The input/output port 207 communicates with a reader-writer. The co-processor 202 is a special calculation device for executing modular calculations, and is used for calculations in anti-symmetric RSA or the like. Many of IC card processors have no co-processor. A data bus 203 interconnects components of the IC card.

[0005] The storage memory 204 includes a ROM (Read Only Memory), a RAM (Random Access Memory), an EEPROM (Electrically Erasable Programmable Read Only Memory) and the like. ROM is a memory device whose contents cannot be rewritten freely, and is mainly used for storing programs. RAM is a memory whose contents can be rewritten freely and are erased if a power supply is intercepted. When the IC card is disconnected from the reader-writer, a supply of the power is intercepted so that the contents of RAM cannot be retained. EEPROM is a memory whose contents can be retained even if a power supply is intercepted. Therefore, EEPROM is used for storing data which may be rewritten and can be retained even if the IC card is disconnected from the reader-writer. For example, the number of prepaid times of a prepaid card is stored in EEPROM because it is updated each time the card is used and the contents thereof are required to be retained even if the card is disconnected from the reader-writer.

[0006] An IC card is used for storing programs and important information in the IC card chip to execute a cipher process. It has been long considered that the difficulty in decryption of a cipher process executed in the IC card is the same as that in decryption of a ciphering algorithm. However, it has been suggested recently that there is a possibility of presuming the contents of a cipher process and a cipher key by measuring and analyzing a consumption current while the cipher process is executed, easier than decryption of a cipher algorithm. The consumption current can be monitored by measuring the current supplied from the reader-write. This possible danger is described in "Smart Card Handbook", by W. Rankl & W. Effing, John Willey & Sons, paragraph 8.5.1.1 "Passive protective mechanism", at p. 263.

SUMMARY OF THE INVENTION

[0007] CMOSs constituting an IC card chip consume current when an output state changes from "1" to "0" or vice versa. The data bus 203 in particular flows a large current when its state changes from "1" to "0" or vice versa, because the data bus has a large electrical capacitance. This suggests a possibility of presuming the operation state in the IC card chip by monitoring the consumption current.

[0008] Fig. 3 shows wave shapes of consumption current during one cycle operation of an IC card chip. Depending upon processed data, the current wave shape becomes different as indicated at 301 and 302. This difference is generated depending upon data on the bus 203 and data being processed by the central processor 201.

[0009] Consider now the data transfer on a pre-charge bus of 16 bits. The pre-charge bus is reset prior to data transfer so that all bits on the bus have a value "0". If the data having the same number of "1" bits and different values, e.g., data of hexadecimal "88" and "11" both having two "1" bits, is transferred to this bus, the current wave shapes are generally the same. This is because the numbers of bits changing from "0" to "1" are the same and the same current is consumed to have similar current wave shapes. If the data having a difference of one "1" bit, e.g., data of hexadecimal "89" and "19" both having three "1" bits, is transferred to this bus, the current wave shape becomes different from that of the data having two "1" bits. This is because the number of bits changing from "0" to "1" changes to three bits and a corresponding current is consumed increasingly. Therefore, as compared to the data having two "1" bits, the consumption current increases in amount corresponding to one bit. There is a regularity that the larger the number of "1" bits, the larger the amplitude of the current wave shape becomes. From this regularity, the transferred data can be presumed.

[0010] The current wave shapes shown in Fig. 3 indicate the total sum of current flowing not only through the bus but also through other components constituting the IC card chip. A microcomputer such as an IC card chip includes a phase during which data is transferred mainly to the bus, a phase during which a CPU operates mainly, a phase during which data is written in a register, and other phases. If the phases are taken into account, it is possible to know by which component a difference between consumption currents was mainly produced, and the data process at the component can be presumed.

[0011] A difference between consumption currents will be described by using as an example the following left shift instruction.

$$\text{shift1 R1} \quad (1)$$

[0012] This instruction shifts the contents of the register R1 to the left, i.e., shifts the bit train in the register to the left, and the value of the most significant bit is entered in a condition code register as a carry. Since the most significant bit in the register R1 is transferred via the data bus to the condition cord register, whether the most significant bit is "0" or "1" can be possibly discriminated by comparing the amplitudes of current wave shapes. If important data is stored in the register R1, there is a possibility of discriminating whether this data is "0" or "1" although the data is only one bit. The cryptographic process, particularly DES, frequently uses an operation of shifting a cipher key. During this shift operation, the current wave shape allowing to presume the data of the cipher key is generated so that there is a possibility that the cipher key is presumed.

[0013] The above-described case is also applied to the operation of the co-processor 202. If the operation contents include any unbalance dependent upon a cipher key, this shift can be presumed from the consumption current, and there is a possibility that the cipher key is presumed.

[0014] An issue associated with the present invention is to reduce the relation between the data process in an IC card chip and its consumption current. If the relation between the data process in an IC card chip and its consumption current can be reduced, it becomes difficult to presume the data process in the IC card chip and the cipher key, from the observed consumption current shapes. The feature of this invention is to make difficult to presume the data process and the cipher key from the consumption current wave shape, by processing the data in the IC card chip after it is transformed.

[0015] These objects are, according to the invention, seived by the features of claims 1, 2, 3, 4 and 13.

[0016] The tamper resistance device, typically an IC card chip, is considered as an information processing equipment which comprises: a storage memory including a program storage unit for storing a program and a data storage unit for storing data; and a central processing unit for executing a data process in accordance with the program, the program including one or more data process means each being a process instruction for giving an execution instruction to the central processing unit. According to the invention, as the method of reducing the relation between the data process in an IC card chip and its consumption current, data is first transformed by using disturbance data and then processed. After this process, the data is untransformed by using the disturbance data to obtain a correct process result. The disturbance data to be used after the data process may be the same disturbance data used for the data process, if necessary. The disturbance data is changed randomly at each data process. With these processes, during each data process, transformed data can be used without using the original data. It becomes therefore difficult to presume the data from current wave shapes.

[0017] Specifically, disturbance data Xi is first generated and the data D1 is transformed by using the disturbance data Xi to generate transformed data H1. The transforming method may be exclusive logical OR, addition, multiplication or the like. During the data process, the transformed data H1 is processed to generate processed and transformed data H2. Since the transformed data H1 is used instead of original data H1, it is difficult to presume the data D1 from the current wave shapes during the process of the transformed data H1. Since the transformed data is generated by using different disturbance data Xi at each process, the transformed data generated at each process is different. Therefore, the current wave shape during the process of the transformed data H1 becomes different at each process. Presuming the transformed data H1 from current wave shapes is therefore meaningless.

[0018] If it is necessary for the disturbance data Xi to be processed in a manner similar to the data D1, the disturbance data Xi is processed to generate processed disturbance data. The processed and transformed data H1 is processed by using the processed disturbance data Xo to generate the processed data D2 which is a result of the input data process for the input data D1.

[0019] If it is necessary to use different data transformation methods, it may be required to connect several data transformations. In such a case, a combination of a data transforming process, a transformed data process, a disturbance data process, and a data untransforming process is used and these several data transformations are connected so as not to process original data.

[0020] According to this invention, it is possible to conceal the information that may be gotten in the permutation process and substitution process for replacing data and in the access process to data tables, during execution of an encryption algorithm. The transformation process that ensures to get the correct data is one of effective methods to be used for data encryption and decryption. In this transformation process, the exclusive logical OR is used to transform data in a data exchanging process, and the transformed data and disturbance data are processed by the same method in the data process.

[0021] A typical structure of the invention is as follows. An information processing equipment comprising: a storage memory including a program storage unit for storing a program and a data storage unit for storing data; a central processing unit for executing a data process in accordance with the program, the program including one or more data process means each being a process instruction for giving an execution instruction to the central processing unit; and input data processing means wherein one data processing means processes input data and outputs the processed data, comprises: data transforming process means for transforming input data D1 by using disturbance data Xi to generate transformed data H1; transformed data processing means for executing an operation process OP1 for the transformed data H1 in place of the operation process OP1 for the input data D1 to be executed by the input data processing means, to generate processed and transformed data H2; disturbance data processing means for executing the operation process OP1 for the disturbance data Xi to generate processed disturbance data Xo; and data untransforming processing means for executing an operation process OP2 for the processed and transformed data H2 by using the processed disturbance data Xo, to generate processed data D2 which is a result of the operation process OP1 for the input data D1.

[0022] The operation process OP1 corresponds, for example, to the process of an embodiment illustrated in Fig. 4 to be described later. The operation process OP1' corresponds, for example, to the process for disturbance data 2 (510 to 513, and 516 to 520).

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Fig. 1 is a diagram showing an example of the structure of hardware of a known IC card.

[0024] Fig. 2 is a diagram showing an example of the structure of hardware of a known IC card chip.

[0025] Fig. 3 is a diagram showing examples of wave shapes of consumption current of an IC card.

[0026] Fig. 4 is a diagram illustrating a procedure of data transformation using one disturbance data according to an embodiment of the invention.

[0027] Fig. 5 is a diagram illustrating a procedure of data transformation using two sets of disturbance data in a nesting state, according to an embodiment of the invention.

[0028] Fig. 6 is a diagram illustrating a procedure of data transformation using two sets of disturbance data in a continuous state, according to an embodiment of the invention.

[0029] Fig. 7 is a diagram illustrating a procedure of data transformation wherein disturbance data is processed in advance, according to an embodiment of the invention.

[0030] Fig. 8 is a diagram illustrating a procedure of data transformation wherein the untransforming processes for the two sets of disturbance data are unified, according to an embodiment of the invention.

[0031] Fig. 9 is a diagram illustrating the overall process flow of DES, according to an embodiment of the invention.

[0032] Fig. 10 is a diagram illustrating the f function process of DES, according to an embodiment of the invention.

[0033] Fig. 11 is a diagram illustrating a transforming process 1, according to an embodiment of the invention.

[0034] Fig. 12 is a diagram illustrating an IP process, according to an embodiment of the invention.

[0035] Fig. 13 is a diagram illustrating a PC-1 process, according to an embodiment of the invention.

[0036] Fig. 14 is a diagram illustrating a PC-2 process, according to an embodiment of the invention.

[0037] Fig. 15 is a diagram illustrating an LS process, according to an embodiment of the invention.

[0038] Fig. 16 is a diagram illustrating a selectable permutation E process, according to an embodiment of the invention.

[0039] Fig. 17 is a diagram illustrating an XOR process between a result of the selectable permutation E process and a cipher key, according to an embodiment of the invention.

[0040] Fig. 18 is a diagram illustrating an S box process, according to an embodiment of the invention.

[0041] Fig. 19 is a diagram illustrating a permutation P process, according to an embodiment of the invention.

[0042] Fig. 20 is a diagram illustrating an XOR process between a result of the permutation P process and a result at the preceding stage.

[0043] Fig. 21 is a diagram illustrating an IP-1 process, according to an embodiment of the invention.

[0044] Fig. 22 is a diagram illustrating an untransforming process, according to an embodiment of the invention.

[0045] Fig. 23 is a diagram illustrating a process of forming a transformed S box table, according to an embodiment of the invention.

[0046] Fig. 24 is a diagram illustrating an i-th transformed S box table forming routine, according to an embodiment of the invention.

[0047] Fig. 25 is an i-th S box table, according to an embodiment of the invention.

[0048] Fig. 26 is a table having transformed data of the i-th S box table of the embodiment.

[0049] Fig. 27 is a table having transformed positions of the i-th S box table of the embodiment.

[0050] Fig. 28 is a selectable permutation E table, according to an embodiment of the invention.

[0051] Fig. 29 is a permutation P table, according to an embodiment of the invention.

[0052] Fig. 30 is a diagram illustrating an encryption process for disturbance data, according to an embodiment of the invention.

[0053] Fig. 31 is a diagram illustrating a transforming calculation process for encryption data for disturbance data, according to an embodiment of the invention.

[0054] Fig. 32 is a diagram illustrating a decryption process for disturbance data, according to an embodiment of the invention.

[0055] Fig. 33 shows an example of an original table according to an embodiment of the invention.

[0056] Fig. 34 shows a table whose contents are modified from those of the table shown in Fig. 33, according to the embodiment of the invention.

[0057] Fig. 35 shows a table whose arrangement is modified from that of the table shown in Fig. 34, according to the embodiment of the invention.

[0058] Fig. 36 is a diagram illustrating a transforming process b, according to an embodiment of the invention.

[0059] Fig. 37 is an IP permutation table according to an embodiment of the invention.

[0060] Fig. 38 is a PC-1 selectable permutation table according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0061] Embodiments of the invention will be described with reference to the accompanying drawings.

[0062] Fig. 1 is a plain view of an IC card. The position of an IC card chip 102 and the number of contacts and their operation assignments of the IC card 101 are defined by ISO 7816 specifications.

[0063] Fig. 2 shows the internal structure of the IC card chip 102. The structure has been described already with respect to conventional techniques. According to this invention, data to be processed by the program 205 is disturbed so that it becomes difficult to presume original data from the wave form of power consumed by the hardware of the IC card chip during data processing. The fundamental concept will be described by taking as an example the following simple instruction train:

logica_shift1 R1 (2)

xor R1 R2 (3)

[0064] The equation (2) is an instruction for logically looping the value in a register R1 to the left. The most significant bit moves to the least significant bit. The result is loaded in the register R1. The exclusive logical OR between the result and the value in a register R2 is calculated by the equation (2), and this result is loaded in the register R2. These operations are performed by this instruction train. Such instructions are frequently used in a cipher algorithm such as DES. Since the equations (2) and (3) use the process data itself, the amplitude of the power consumption is changed with the contents of the process data. There is therefore a possibility of presuming the data by monitoring the power consumption shape.

[0065] In order for the equations (2) and (3) not to use the process data itself, the instruction train is changed to:

xor X1 R1 (4)

xor X2 R2 (5)

logica_shift1 R1 (6)

xor R1 R2 (7)

logica_shift1 X1 (8)

$$\text{xor X1 X2} \tag{9}$$

$$\text{xor X2 R2} \tag{10}$$

where X1 and X2 are arbitrary random numbers and are data for disturbance. With the equations (4) and (5), an exclusive logical OR between R1 and X1 and between R2 and X2 is calculated to execute a transforming process for transforming original data. Although the equations (6) and (7) are expressed same as the equations (2) and (3), the values R1`and R1 in the equations (6) and (7) are not the values of original data because the transforming process was executed. With the equations (8) and (9), the disturbance data itself is processed. With the equation (10), an exclusive logical OR between the processed disturbance data and the process result of the equation (7) is calculated to execute an untransforming process for recovering the original data.

[0066] These processes will be specifically described by using particular numerical values. R1 and R2 have the following values:

$$\text{R1:11001010} \tag{11}$$

$$\text{R2:01010111} \tag{12}$$

[0067] The value of R1 processed by the equation (2) is:

$$\text{R1:10010101} \tag{13}$$

[0068] The process result by the equation (3) is:

$$\text{R2:11000010} \tag{14}$$

[0069] A modification of this invention will be described. First, the disturbance data has the following values, with the same values of R1 and R2 being used:

$$\text{X1:10010111} \tag{15}$$

$$\text{X2:00111010} \tag{16}$$

[0070] The process result by the equations (4) and (5) are:

$$\text{R1:01011101} \tag{17}$$

$$\text{R2:01101101} \tag{18}$$

[0071] The process results by the equations (6) and (7) are:

$$\text{R1:10111010} \tag{19}$$

$$\text{R2:11010111} \tag{20}$$

[0072] The process results of the data X1 and X2 for disturbance by the equations (8) and (9) are:

$$X1:00101111 \quad (21)$$

$$X2:00010101 \quad (22)$$

[0073] The result of the untransforming process by the equation (10) is the same as the result of the original data process indicated by the equation (14):

$$R2:11000010 \quad (23)$$

[0074] As shown in this example, the transformed original data and the disturbance data are processed in a similar manner, and the results are untransformed to recover the original value. Since this data process does not use original data itself, it is difficult to presume the original data from the current wave shape, although the transformed data can be presumed.

[0075] The above example using particular numerical values will be expressed by a general format. The actual process is as follows:

$$Output(j) = f(Input(i)) \quad (24)$$

[0076] This process means that i inputs are subjected to a process f to output j outputs. In the example shown by the equations (2) and (3), there are two inputs R1 and R2 and one output stored in the register R2. In order that it becomes difficult to presume original data from the current wave shape during the process of the equation (24), the following equations are used:

$$InputX(i) = h(Input(i), X(i)) \quad (25)$$

$$OutputX(j) = f(InputX(i)) \quad (26)$$

$$Xoutput(j) = f(X(i)) \quad (27)$$

$$Output(j) = g(OutputX(i), Xoutput(i)) \quad (28)$$

[0077] The equation (25) transforms the input data Input(i) by using disturbance data X(i) to generate the transformed input data InputX(i). This transformation operation is represented by h. The equation (26) is a data process for processing data by using transformed input data. The equation (27) is a disturbance data process for processing the disturbance data in a manner similar to the input data. The equation (28) is an untransforming process for reversely processing the transformed input data process result OutputX(j) and the disturbance data process result Xoutput(j). The untransforming operation is represented by g.

[0078] The process by the equation (25) corresponds to the equations (4) and (5) in the above-described example, and the transformation operation h corresponds to the exclusive logical OR. The transformed input data process by the equation (26) corresponds to the equations (6) and (7). The euqations (8) and (9) show the data processing for the disturbance data in the equation (27). The untransforming process by the equation (28) corresponds to the equation (10). The transformation operation g corresponds to the exclusive logical OR.

[0079] Which operations are selected for the transformation operation h and untransformation operation g is determined by the characteristics of the data process f. In the process by the equations (2) and (3), the exclusive logical OR is the transformation operation h and also the untransformation (inverse) operation g. For a shift operation and an XOR operation, by selecting the exclusive logical OR as the transformation operation h, the untransformation (inverse) operation g is the exclusive logical OR. This is because, the exclusive logical OR between the same data is logical 0 and the operation of the exclusive logical OR is vanished.

[0080] If the data process f is addition/subtraction, addition or subtraction can be selected as the transformation operation h and the corresponding inverse operation g is subtraction or addition. For example, the following operation:

$$\text{Output} = \text{Input}(1) + \text{Input}(2) - \text{Input}(3) \tag{29}$$

can be transformed into:

$$\text{InputX}(1) = \text{Input}(1) + X(1) \tag{30}$$

$$\text{InputX}(2) = \text{Input}(2) + X(2) \tag{31}$$

$$\text{InputX}(3) = \text{Input}(3) + X(3) \tag{32}$$

[0081] By processing the transformed input data, the process result of the transformed input data can be obtained:

$$\text{OutputX} = \text{InputX}(1) + \text{InputX}(2) - \text{InputX}(3) \tag{33}$$

[0082] The disturbance data is processed in the similar manner:

$$\text{Xoutput} = X(1) + X(2) - X(3) \tag{34}$$

[0083] Next, the untransforming process is executed:

$$\begin{aligned}\text{Output} = g(\text{Xoutput}) &= \text{OutputX} - \text{Xoutput}\\ &= \text{InputX}(1) + \text{InputX}(2) - \text{InputX}(3)\\ &\quad - (X(1) + X(2) - X(3))\\ &= \text{Input}(1) + \text{Input}(2) - \text{Input}(3)\end{aligned} \tag{35}$$

[0084] In the above manner, the original data can be obtained. This is because the original data can be obtained, in the addition/subtraction calculation, by adding a certain value and subtracting the added value from the last process result.

[0085] For the data process f of multiplication/ division, the transforming process and untransforming process can be realized by selecting multiplication or division as the transformation operation h and division or multiplication as the untransformation operation. This is because, similar to the addition/subtraction, the original data can be obtained, in the multiplication/division calculation, by multiplying (dividing by) a certain value and dividing (multiplying) the last process result by the value.

[0086] For the data process f of addition and subtraction in modular calculation, addition and subtraction of the number multiplying the modulus N by a voluntary integer can be selected as the transformation operation h. For example, consider the following addition and subtraction in modular calculation:

$$\text{Output} = (\text{Input}(1) + \text{Input}(2) - \text{Input}(3)) \bmod N \tag{36}$$

[0087] The input data Input (i) is transformed:

$$\text{InputX}(i) = \text{Input}(i) + k(i) * N \tag{37}$$

[0088] By using the transformed input data, the addition and subtraction in modular calculation is executed:

$$\text{OutputX} = (\text{InputX}(1) + \text{Inputx}(2) - \text{Inputx}(3)) \bmod N \qquad (38)$$

[0089] The equation (38) can be transformed by using the equation (37):

$$\begin{aligned}\text{OutputX} &= ((\text{Input}(1) + k(1) * N)\\ &\quad + (\text{Input}(2) + k(2) * N)\\ &\quad - (\text{Input}(3) + k(3) * N)) \bmod N\\ &= ((\text{Input}(1) + \text{Input}(2) - \text{Input}(3))\\ &\quad + (k(1) * N + k(2) * N - k(3) * N)) \bmod N \qquad (39)\end{aligned}$$

[0090] By using the property of the modular calculation:

$$0 = k * N \bmod N \qquad (40)$$

the value in the second parentheses of the equation (3) becomes 0 and the equation (39) is given by:

$$\text{OutputX} = (\text{Input}(1) + \text{Input}(2) - \text{Input}(3)) \bmod N \qquad (41)$$

[0091] Namely, the calculation result of the transformed input data is the same as the calculation result of the original data. This is an example that the disturbance data process and untransforming process are unnecessary if the above-described feature of the modular calculation is incorporated. The disturbance data process result:

$$\text{Xoutput}(i) = (k(1) * N + k(2) * N - k(3) * N) \bmod N \qquad (42)$$

is 0 so that the disturbance data process and untransforming process are unnecessary.

[0092] For the data process f of multiplication in modular calculation, an integer multiple of the modulus N added with 1 can be used for the transformation operation h. Consider for example the following multiplication in modular calculation:

$$\text{Output} = \text{Input}(1) * \text{Input}(2) * \text{Input}(3) \bmod N \qquad (43)$$

[0093] The input data Input(i) is transformed:

$$\text{InputX}(i) = \text{Input}(i) * (k(i) * N + 1) \qquad (44)$$

[0094] By using the transformed input data, the multiplication modular calculation is executed:

$$\text{OutputX} = \text{InputX}(1) * \text{InputX}(2) * \text{InputX}(3) \bmod N \qquad (45)$$

[0095] The equation (45) can be transformed by using the equation (44):

$$\begin{aligned}\text{OutputX} &= (\text{Input}(1) * (k(1) * N + 1))\\ &\quad * (\text{Input}(2) * (k(2) * N + 1))\end{aligned}$$

$$\begin{aligned} &* (\mathrm{Input}(3) * (k(3) * N + 1)) \bmod N \\ &= (\mathrm{Input}(1) * \mathrm{Input}(2) * \mathrm{Input}(3)) \\ &* ((k(1) * N + 1) * (k(2) * N + 1) \\ &* ((k(3) * N + 1)) \bmod N \end{aligned} \tag{46}$$

[0096] By using the property of modular calculation:

$$0 = k * N \bmod N \tag{47}$$

the equation (46) is given by:

$$\begin{aligned} \mathrm{OutputX} &= (\mathrm{Input}(1) * \mathrm{Input}(2) * \mathrm{Input}(3)) \\ &* (\ 1*1*1) \bmod N \\ &= \mathrm{Input}(1) * \mathrm{Input}(2) * \mathrm{Input}(3) \bmod N \end{aligned} \tag{48}$$

[0097] Namely, the calculation result of the transformed input data is the same as the calculation result of the original data. This is also an example that the data processing of the disturance data and the untransform operation are unnecessary due to the property of modular calculation.

[0098] For the function f of multiplication by an integer in modular calculation with modulus N, the transform operation h can be selected as multiplication by an invertible number x in this modular calculation. In this case, g is the the multiplication by Y such that:

$$1 = X * Y \bmod N \tag{49}$$

[0099] A simple example of such numerical values is that X = 2 and Y = (N+1)/2; (N is an odd number). The process result of original data can be obtained by multiplying X as the transformation operation, and multiplying Y in the untransforming process by the number of X multiplication times. Consider for example the following addition and subtraction in modular calculation:

$$\mathrm{Output} = \mathrm{Input}(1) * \mathrm{Input}(2) * \mathrm{Input}(3) \bmod N \tag{50}$$

[0100] The input data Input(i) is transformed:

$$\mathrm{InputX}(i) = \mathrm{Input}(i) * X \tag{51}$$

[0101] By using the transformed input data, the addition/subtraction modular calculation is performed:

$$\mathrm{OutputX} = \mathrm{InputX}(1) * \mathrm{InputX}(2) * \mathrm{InputX}(3) \bmod N \tag{52}$$

[0102] If a value multiplied by Y by the number of X multiplication times is selected for the untransforming process g, the original data can be obtained by performed the untransforming process g for the outputX:

$$\begin{aligned} \mathrm{Output} &= \mathrm{OutputX} * Y * Y * Y \bmod N \\ &= \mathrm{InputX}(1) * \mathrm{InputX}(2) * \mathrm{InputX}(3) \end{aligned}$$

$$\begin{gathered}
* Y * Y * Y \bmod N \\
= \mathrm{Input}(1) * X * \mathrm{Input}(2) * X * \\
\mathrm{Input}(3) * X * Y * Y * Y \bmod N \\
= \mathrm{Input}(1) * \mathrm{Input}(2) * \mathrm{Input}(3) \\
* X * X * X * Y * Y * Y \bmod N \\
= \mathrm{Input}(1) * \mathrm{Input}(2) * \mathrm{Input}(3) \\
* X * Y * X * Y * X * Y \bmod N \\
= \mathrm{Input}(1) * \mathrm{Input}(2) * \mathrm{Input}(3) \bmod N \qquad (53)
\end{gathered}$$

[0103] For the equation (53), the feature of the equation (49) was used. In this example, although the disturbance data process is unnecessary, if the inverse is multiplied in the modulus N by the number of disturbance data multiplication times, in the untransforming process, the correct result can be obtained.

[0104] It is also necessary to disturb a retrieval operation of data from a table in order not to presume data from the current wave shape. An example of disturbance of table data and disturbance of table address will be described by taking as an example retrieving data from a table shown in Fig. 33.

[0105] An exclusive logical OR between the table data shown in Fig. 33 and disturbance data X1 is calculated. For example, the disturbance data of "9" is selected and an exclusive logical OR between the table value and "9" is calculated. The results are shown in the table of Fig. 34. Next, in order to disturb the table address, an exclusive logical OR between the row number and selected disturbance data X2 of "3" and between the column number and selected disturbance data X3 of "2" is calculated to rearrange the table. The results are shown in Fig. 35. The data 3301 of "0" at the first row and second column of the original table shown in Fig. 33 is changed to the data 3401 of "9" in the table shown in Fig. 34 after the exclusive logical OR of the disturbance data X1 is calculated. After the exclusive logical ORs between the row number and disturbance data X2 and between the column number and disturbance data X3 is calculated, the data 3401 moves to the position of data 3501. Such tables are prepared in order to disturb the retrieval operation of data from the table.

[0106] It is assumed herein that a row number variable Gyou and a column number variable Retsu have been transformed already through an exclusive logical OR of disturbance data Y1 and Y2 before the address calculation is executed. Namely, it is assumed that correct row and column numbers Gyou and Retsu cannot be obtained until the exclusive logical OR between the Y1 and Y2 and the Gyou and Retsu is calculated. This can be expressed by the following relations:

$$\mathrm{Gyou} = \mathrm{GyouYl} \ \mathrm{xor} \ \mathrm{Y1} \qquad (54)$$

$$\mathrm{Retsu} = \mathrm{RetsuY2} \ \mathrm{xor} \ \mathrm{Y2} \qquad (55)$$

[0107] However, if the table shown in Fig. 33 is used for this untransforming process, the correct address data is used so that the address data may be presumed from the current wave shape. Therefore, first, the disturbance data X2 and X3 used for disturbing the row and column numbers when the table shown in Fig. 35 was formed, are used:

$$\mathrm{GyouY1X2} = \mathrm{GyouY1} \ \mathrm{xor} \ \mathrm{X2} \qquad (56)$$

$$\mathrm{RetsuY1X3} = \mathrm{RetsuY2} \ \mathrm{xor} \ \mathrm{X3} \qquad (57)$$

[0108] The disturbance data used is then subjected to the untransforming process:

$$\text{GyouX2} = \text{GyouY1X2 xor Y1} \tag{58}$$

$$\text{RetsuX3} = \text{RetsuY2X3 xor Y2} \tag{59}$$

[0109] With this procedure, the correct row and column numbers are not used so that it is difficult to presume the correct row and column numbers from the current wave shape. By using GyouX2 and RetsuX3 and referring to the table TableX1X2X3 shown in Fig. 35, data X1 is obtained:

$$\text{DataX1} = \text{TableXIX2X3(GyouX2, RetsuX3)} \tag{60}$$

[0110] Since the table shown in Fig. 35 is already transformed by the disturbance data X1, the disturbance data X1 is used in the succeeding process. The processes by the equations (56) to (60) do not use original data.

[0111] Each time a predetermined amount of processes is executed, the table data disturbance data X1 and row and column number disturbance data X2 and X3 are randomly generated to transform the tables. With this transforming process, the tables are transformed so that it is difficult to presume the data from the current wave shape.

[0112] In the foregoing, the type of disturbance data and a method of transforming data have been described. Next, the sequential processes therefor will be described. Fig. 4 illustrates an embodiment of a fundamental information concealment procedure using disturbance data.

[0113] Fig. 4 illustrates a fundamental procedure. A disturbance data generating unit generates disturbance data Xi (401). As a general method therefor, there is a method of generating a random number having a necessary length by using a random number generator or a pseudo random number generator. Next, a data transforming process unit (406) transforms input data D1 (405) by the disturbance data Xi to generate transformed data H1 (407). As described earlier, the transforming process may be an exclusive logical OR, addition and subtraction, multiplication and division, or the like. A transformed data process unit processes the transformed data H1 (408) to generate processed and transformed data H2. A disturbance data process unit performs (403) a similar data process to that of the input data to generate processed disturbance data Xo (404). A data untransforming process unit obtains (410) correct processed data D2 by using the processed disturbance data Xo and processed and transformed data D2 (411). The process to be executed by the data transforming unit (406) and data untransforming unit may include, as described earlier, an exclusive logical OR, addition and subtraction, multiplication and division, modular calculation, or the like.

[0114] In the embodiment shown in Fig. 5, two sets of disturbance data are used. An information concealment procedure using first disturbance data contains another information concealment procedure using second disturbance data. The main flow is similar to the embodiment shown in Fig. 4. Transformed data H1 (507) transformed by the first disturbance data is processed. The processed and transformed data H2 (509) is transformed by a second data transforming process unit (510) by using the second disturbance data X2i to thereby generate processed and transformed data H3 (511). This processed and transformed data H3 is processed by a second deformed data process unit (512) to generate processed and transformed data H4. A second data untransforming process unit (520) untransforms the second disturbance data to generate processed and transformed data H5 (521). A first data untransforming process unit (514) untransforms the first disturbance data to obtain correct processed data D2 (515). An example of transformation using an exclusive logical OR is as follows:

$$\text{H1} = \text{D1 xor X1i}$$

$$\text{H2} = \text{f1(H1)}$$

$$\text{X1o} = \text{f1(X1i)}$$

$$\text{H31} = \text{H2 xor X2i}$$

$$\text{H32} = \text{D2 xor X2i}$$

$$\text{H4} = \text{f2(H31, H32)}$$

$$\text{X2o} = \text{f2(X2i, X2i)}$$

$$H5 = H4 \text{ xor } X2o$$

$$D2 = H5 \text{ xor } X1o \qquad (61)$$

The data processes are represented by f1 and f2. As in this example, since the second data process f2 uses another data D2 and this data D2 is transformed by the second disturbance data, the procedure of this embodiment is effective.

[0115] Also in the embodiment shown in Fig. 6, two sets of disturbance data are used. A significant difference from the embodiment shown in Fig. 5 is that an information concealment procedure using first disturbance data is continuous with another information concealment procedure using second disturbance data. In this procedure of concealing the process using correct data, prior to the untransforming process for the first disturbance data, the input data is further transformed by using the second disturbance data. Transformed data H1 (609) transformed by the first disturbance data is processed by a first transformed data process unit (610). The processed and transformed data H2 (611) is transformed by a second transformed data generating unit (612) by using the second disturbance data H2 (611) to generate processed and transformed data H3 (613). A first data untransforming process unit (605) untransforms for the first disturbance data. This process result of processed and transformed data H4 (606) is used for a second transformed data process unit (614) to generate processed and transformed data H5 (615). A second data untransforming process unit (616) untransforms the data to generate correct processed data D2 (617). An example of transformation using an exclusive logical OR is as follows:

$$H1 = D1 \text{ xor } X1o$$

$$H2 = f1(H1)$$

$$X1o = f1(X1i)$$

$$H3 = H2 \text{ xor } X2i$$

$$H4 = H3 \text{ xor } X1o$$

$$H5 = f2(H4)$$

$$X2o = f2(X2i)$$

$$D2 = H5 \text{ xor } X2i \qquad (62)$$

[0116] This procedure is effective for the case wherein there are a plurality of processes and a plurality set of disturbance data are used.

[0117] In the embodiment shown in Fig. 7, the disturbance data is processed in advance in order to make the procedure efficient. A disturbance data process unit generates in advance processed disturbance data Xo (703) which is stored in a processed disturbance data storage unit (706). During the procedure, a data untransforming process unit (713) reads the stored processed disturbance data (714) to use it. This procedure is efficient if similar data processes are executed a plurality of times. However, since the disturbance data is used a plurality of times, it is more effective to change the disturbance data each time the data process is executed, as in the embodiment shown in Fig. 4. This can be settled from the tradeoff between the process time and the information security.

[0118] In the embodiment shown in Fig. 8, the untransforming processes for the first and second disturbance data is unified, and thereafter, by using the unified result, the data is untransformed. First and second disturbance data process units 803 and 807 process the first and second disturbance data to generate processed disturbance data X1o and X2o. These data are unified by a data untransforming and unifying unit to generate unified and processed disturbance data Xo. By using this data, an untransforming process unit (820) untransforms the processed and transformed data H4 (819) processed by first and second transformed data process units (814 and 818) to generate correct processed data D2. With this procedure, the processed disturbance data is unified and an unified untransforming process is executed thereafter, instead of independently executing the untransforming process. This procedure is effective for the case wherein the untransforming process takes a long process time.

[0119] Next, embodiments using symmetric cryptographic DES (data encryption standard) will be described. The invention is applicable to other cryptographic systems.

[0120] DES performs encryption and decryption of 64-bit data (plain text or cipher text) by using a cipher key of

56-bits. Since the same cipher key is used for both encryption and decryption, DES is called a symmetric cryptography. As trump cards are turned randomly, bits of a plain text (to be encrypted) are randomly exchanged and enciphered. Data exchange is performed in accordance with the cipher key. When data is deciphered, bits of a cipher text are exchanged in the reverse order of the enciphering to recover the original data. Data exchange of DES uses two exchange methods one being a one-bit unit basis and the other being a plural-bit unit basis. The former is called permutation and the latter is called substitution.

[0121] Referring to Fig. 9, DES cryptography will be described. A transforming process a (901), a transforming process b (904), and an untransforming process (916) pertain to the present invention and are not relevant to the essential cryptography of DES. A cipher text is subjected first to initial permutation (IP) 902. This permutation is performed by using an initial permutation table to exchange 64-bit data of the cipher text on the one-bit unit basis. A series of such operations is repeated sixteen stages to inverse permutation (IP^{-1}) 915 of the initial permutation.

[0122] At each stage, a process called an f function 903 is calculated by inputting data of 32 bits of either the first or second half at the preceding stage and the cipher key, and then an exclusive logical OR operation 909 is performed by using the output of the f function and 32 bits of the remaining half at the preceding stage. Data of the cipher key is also exchanged. Data of the cipher key is first subjected to selectable permutation PC-1 (905) by using a table PC-1. Thereafter, data of the cipher key is subjected to selectable permutation PC-2 (908) by using a table PC-2. At the next stage, each set of 28 bits of the cipher key rounded in accordance with an RS table is used.

[0123] In this embodiment, before the IP process, the transforming process a (901) for transforming a plain text, transforming process b (904) for untransforming a cipher key, and lastly untransforming process (916) are additionally executed. The transforming process a (901) transforms a plain text so as to later process the transformed plain text and so as not to process the plain text itself by the IP process (902) and f function process (903). Data of the plain text therefore becomes hard to be presumed from the current wave shape during the data process. The transforming process b (904) transforms a cipher key so as to later process the transformed cipher key and so as not to process the cipher key itself by the PC-1 process (905), LS process (907), PC-2 process (908) and f function (903). Data of the cipher key therefore becomes hard to be presumed from the current wave shape during the data process.

[0124] The process by the f function is illustrated in Fig. 10. Data input to the f function is subjected to selectable (expanding) permutation by using an E selectable permutation matrix (1002). Next, an exclusive logical OR is calculated between the cipher key and a result of the selectable permutation for the input data (1003), an S box process is executed (1004), and a P permutation process is executed (1005). In the S box process, each 6-bit set is extracted from 48 bits which are a result of the exclusive logical OR at 1003, to acquire the row and column numbers of an S box table and generate 4-bit data. The contents of the S box table change with the position of each 6-bit set. The P permutation process exchanges the bit positions of 32 bits by using a P permutation table.

[0125] The transforming process a (901) and transforming process b (902) are fundamentally the same. With reference to Fig. 11, the transforming process a for transforming data of a plain text will be described. Disturbance data X1 is randomly generated. The disturbance data is generated by using a random number generator or a pseudo random number each time an encryption (or decryption) process of DES is performed (1102). Different disturbance data is therefore used for each process. Next, an XOR (exclusive logical OR) between the disturbance data X1 and a plain text P1 is calculated to generate a transformed plain text (PX1 (1103). Although a plain text of DES has 64 bits, the random number may be either 64 bits or 8 bits. In this case, if the number of bits of the random number is smaller than 64 bits, it is necessary to expand it to obtain the disturbance data X1 of 64 bits. If the generated random number has 8 bits, this number may be repeated eight times to generate the disturbance data X1 of 64 bits. Since the exclusive logical OR (XOR) was used for transformation, XOR between the disturbance data X1 and transformed plain text PX1 generates the plain text P.

[0126] The transforming process b (904) for transforming data of a cipher key is illustrated in Fig. 36. A different point from the embodiment shown in Fig. 11 is that a cipher key K and disturbance data X2 are used in place of a plain text and disturbance data X1. A cipher key of DES has 64 bits same as that of a plain text. With the transforming process b, a transformed cipher key KX2 is generated.

[0127] Next, the IP process (902) will be described. The IP process exchanges the positions of a plain text having 64 bits by using a table shown in Fig. 37. In accordance with this table, the first bit of an output is exchanged with the 58-th bit of an input, the second bit of the output is exchanged with the 50-th bit of the input, ..., and the 64-th bit of the output is exchanged with the 7-th bit of the input. The IP process of this embodiment will be described with reference to Fig. 12. First, the transformed plain text PX1 is subjected to the IP process to generate an IP processed and transformed plain text PX1IP (1202). Bit exchange is performed conforming to the table shown in Fig. 37. Next, the disturbance data X1 is also subjected to the IP process to generate an IP processed and transformed disturbance data X1IP (1203). An exclusive logical OR between the IP processed and transformed plain text PX1IP and IP processed and transformed disturbance data X1IP can generate a result of IP processed plain text. This is because a relation is retained in which the disturbance data moves in a similar manner to the transformed plain text PX1 because of a bit motion of the IP process and so the exclusive logical OR of a one-bit unit basis generates correct data. The lower 32 bits of the result of the IP process are used by a first stage f function (903) and a second stage exclusive logical OR, whereas the upper 32 bits are input for the exclusive logical OR (909).

[0128] In the IP process, the values of bits of the transformed plain text PX1 are different from the values of bits of the original plain text. It is therefore difficult to presume the data of the original plain text from the current wave shape during the IP process. The larger the number of "1" bits, the large the consumption current. However, the number of "1" bits of the transformed plain text is related not at all to the number of "1" bit of the original plain text, and so it is difficult to presume the data of the original plain text. As above, since the plain text is transformed by using disturbance data, presuming the original data is difficult even if the current wave shape during the process is monitored.

[0129] With the PC-1 process, a PC-1 transformation table shown in Fig. 38 is used, a cipher key of 64 bits is changed to a cipher key of 56 bits by removing the parity bits of 8 bits, and the order of 56 bits is exchanged. The table shown in Fig. 38 is used in a similar manner to the table shown in Fig. 37. An exclusive logical OR between the PC-1 processed and transformed cipher key KX2PC1 and PC-1 processed and transformed disturbance data X2PC1 can generate a correct PC-1 processed and transformed cipher key.

[0130] With the LS process, the cipher key of 56 bits generated by the PC-1 process is divided into right 28 bits and left 28 bits which are then shifted one bit or two bits to the left in accordance with an LS table. This embodiment will be described with reference to Fig. 15. First, at 1502 the PC-1 processed and transformed cipher key KX2PC1 is subjected to the LS process to generate a PC-1 and LS processed and transformed cipher key KX2PC1LS. At 1503 the PC-1 processed disturbance data X2PC1 is subjected to the LS process to generate a PC-1 and LS processed disturbance data X2PC1LS. Since the LS process also uses bit position exchange, an exclusive logical OR between the PC-1 and LS processed and transformed cipher key KX2PC1LS and PC-1 and LS processed disturbance data X2PC1LS can generate a correct LS processed cipher key. Since the LS process also uses the disturbance data and the data of the cipher key actually processed is different from the original cipher key, it is difficult to presume the cipher key even if the current wave shape is monitored.

[0131] The PC-2 process executes a reduction permutation for changing the 56-bit data generated by the LS process to 48-bit data in accordance with a PC-2 table. At 1402, the PC-1 and LS processed and transformed cipher key KX2PC1LS is subjected to the PC-2 process to generate a PC-1, LS and PC-2 processed and transformed cipher key KX2PC1LSPC2. At 1403, the PC-1 and LS processed disturbance data X2PC1LS is subjected to the PC-2 process to generate a PC-1, LS and PC-2 processed disturbance data X2PC1LSPC2. Basically, this PC-2 process uses the table for permutation so that it is fundamentally the same as the PC-1 process.

[0132] Next, the process for the f function 903 will be described. As shown in Fig. 10, the f function includes a selectable permutation E process (1002), an exclusive logical OR (1003) between a cipher key and an execution result of selectable permutation, an S box process (1004), and a P permutation process (1005).

[0133] The selectable permutation E process will be described with reference to Fig. 16. Similar to the IP process, the selectable permutation E process exchanges the order of bits by using a permutation table shown in Fig. 28. At 1602 the IP processed and transformed plain text PXIP is subjected to the selectable permutation E process to generate an IP processed, E permutated and transformed plain text PXIPE. At 1603 the IP processed disturbance data XIP is subjected to the selectable permutation E process to generate an IP processed, E permutated disturbance data XIPE. Similar to the IP process and PC-1 process, an exclusive logical OR between the IP processed, E permutated and transformed plain text PXIPE and IP processed, E permutated disturbance data XIPE can generate a correct IP processed, E permutated plain text. Since the values of bits exchanged by using the permutation E table are different from those of original bits, it is difficult to presume the correct data even if the current wave shape is monitored during this process.

[0134] Next, the second process (1003) of the f function, i.e., an exclusive logical OR between the cipher key and an execution result of selectable permutation, will be described with reference to Fig. 17. At 1702 an XOR is calculated between the IP processed, E permutated and transformed plain text PXIPE generated from the plain text and the PC-1, LS and PC-2 processed and transformed cipher key KX2PC1LSPC2 generated from the cipher key to generate 48-bit S box input data SinputX which is used as an input for the S box process. Next, at 1703 an XOR is calculated between the IP processed, E permutated disturbance data XIPE generated from the disturbance data for the plain text and the PC-1, LS and PC-2 processed disturbance data X2PC1LSPC2 generated from the disturbance data for the cipher key to generate S box input data disturbance data XSinput which is used as the disturbance data for the S box input data SinputX. Basing upon the characteristics of an exclusive logical OR, the S box input data disturbance data XSinput can be generated by an XOR between the two sets of disturbance data (the IP processed, E permutated disturbance data XIPE and the PC-1, LS and PC-2 processed disturbance data X2PC1LSPC2). This will be clarified by using a simple example. A plain text is represented by P, a cipher key is represented by K, a transformed plain text is represented by PX1, and a transformed cipher key is represented by KX2. The relations among them are given by the following equations (63) and (64) where X1 and X2 are disturbance data for the plain text and cipher key, respectively:

$$PX1 = P \text{ xor } X1 \quad (63)$$

$$KX2 = K \text{ xor } X2 \quad (64)$$

[0135] If an execution result of the exclusive logical OR between P and K is represented by Z, then the relation between Z and an execution result Z1 of the exclusive logical OR between PX1 and PX2 is given by:

$$Z = P \text{ xor } K \quad (65)$$

$$\begin{aligned} Z1 &= PX1 \text{ xor } KX2 \\ &= (P \text{ xor } X1) \text{ xor } (K \text{ xor } X2) \\ &= P \text{ xor } X1 \text{ xor } K \text{ xor } X2 \\ &= (P \text{ xor } K) \text{ xor } (X1 \text{ xor } X2) \\ &= Z \text{ xor } (X1 \text{ xor } X2) \quad (66) \end{aligned}$$

[0136] It can be understood from the above equation that as the disturbance data for recovering the correct data of Z1, the exclusive logical OR between P and K disturbance data can be used. In the exclusive logical OR process between the cipher key and the execution result of selectable permutation, the S box input data disturbance data XSinput can be used as the disturbance data for the S box input data SinputX, the S box input data disturbance data XSinput being generated by an XOR between the IP processed, E permutated disturbance data XIPE generated from the disturbance data for the plain text and the PC-1, LS and PC-2 processed disturbance data X2PC1LSPC2 generated from the disturbance data for the cipher key.

[0137] Next, the S box process will be described with reference to Fig. 18. Eight S boxes are formed each being constituted of 6 bits of the S box input data SinputX. The first S box used in DES is shown in Fig. 25. Although the format of each of the eight S box is the same, the data in each field is different. In the S box process for each S box, first the sub-data SubSinputX(i) of 6 bits is derived from the S box input data Sinput at the upper i-th (1805). An XOR is calculated between this SubSinputX(i) and address disturbance data Xsa(i) for an S box table transformed in advance from the S box, to generate SubSinputXXsa(i) (1806). An XOR is calculated between this SubSinputXXsa(i) and six bits of the S box input data disturbance data XSinput at the upper i-th, to generate SubSinputXsa(i) (1807). This SubSinputXsa(i) is the XORed data of the address disturbance data Xsa(i) and the correct address data to be used for deriving the i-th S box. Since the exclusive logical OR (XOR) between SubSinputX(i) and XSinput(i) recovers correct data, an XOR between SubSinputX(i) and Xsa(i) is calculated and the XOR between the result and XSinput(i) is calculated. With this method, it is not necessary to process the original data so that the original data is difficult to be presumed from the current wave shape. Next, an address of the transformed S box table is calculated by using SubSinputXsa(i) (1808). Since the address for accessing the original S box table is transformed, it is also necessary to transform the table. By using the calculated address, S box output data SoutX3(i) is retrieved from the transformed S box table S(i) (1809). At the same time, disturbance data X3(i) for the S box output data SoutputX3(i) is retrieved (1810). After the eight S boxes are processed, data of SoutputX3(i) and X3(i) for i = 1 to 8 is connected together to generate SoutputX3 and X3. SoutputX3 is used as the process data and X1 is used as the disturbance data in the succeeding processes.

[0138] Next, a method of generating the transformed S box table will be described with reference to Figs. 23 and 24. Address disturbance data Xsa(i) and data disturbance data X3(i) are generated from an S(i) box (2306). Xsa(i) has 6 bits and X3(i) has 4 bits. The disturbance data X3 has 32 bits collected from eight X3(i) each having 4 bits. Next, a transformed S(i) box table forming routine is called (2307). The i-th transformed S box table forming routine will be described with reference to Fig. 24. k is used for designating a row number, and 1 is used for designating a column number. The process for the k-th row and 1-th column is illustrated from 2408 to 2413. The first S box table is shown in Fig. 25. First, data d at the k-th row and 1-th column is picked up from the i-th original S box (2408). An exclusive logical OR between the data d and the disturbance data X3(i) is calculated to generate data d2 (2409). If the disturbance data is "7", the transformed data of the original S box data at 2504 is indicated at 2604. This operation is executed for all the fields to obtain a transformed S box table shown in Fig. 26. This table shown in Fig. 26 is formed through exclusive logical OR operations between the first S box data and the disturbance data "7".

[0139] Next, the address is disturbed. First, Xsa1 is formed from two bits including the upper first bit and the lower first bit of Xsa(i), and Xsa2 is formed from four bits including the bits from the upper second bit to upper fifth bit of Xsa (i). This process is originated from the S box address calculation method. By representing the row and column numbers of the table shown in Fig. 26 by k and 1, exclusive logical OR operations between the Xsa1 and Xsa2 for respective row and column are executed (2412). By representing the new row and column numbers by k2 and 12, the data d2 is stored in the i-th transformed S box table S(i) at the k2-th row and 12-th column (2413). An example of this process is illustrated in Fig. 27. The table shown in Fig. 27 is formed by using disturbance data "2" and "9" for the row and column shown in Fig. 26. In this table, for the simplicity purpose, the position of data at each row and each column is not changed and only the row and column numbers are changed. The data "12" indicated at 2504 at the third row and first column of the table shown in Fig. 25 is moved to the first row and eighth column in Fig. 27 and its value is changed to "11". In this example, the data disturbance data is 7", and the address disturbance data has the row number of "2" and the column number of "9". In this manner, the eight S boxes are transformed. In this embodiment, this process is executed at the first stage of DES. The transformed S boxes are used at sixteen stages of DES.

[0140] After the S box process, 32-bit SoutputX3 is used as process data and 32-bit X3 is used as disturbance data, which are supplied to the permutation P process (1005) which is the last process of the f function. The permutation P process will be described with reference to Fig. 19. SinputX3 supplied from the S box process is subjected to the permutation P process to generate SinputX3P (1902). The disturbance data X3 for SinputX3 is subjected to the permutation P process to generate X3P (1903). A table used for the permutation P process is shown in Fig. 29. This table is used in a similar manner to that of the IP process table.

[0141] After the f function process is completed, an XOR between a result of the permutation P process and a result at the preceding stage is calculated (909, 914). Specifically, an XOR is calculated between SinputX3P obtained by the permutation P process for the S box process result and a result at the preceding stage (2002). An XOR is calculated between X3P and the disturbance data X at the preceding stage (2003). This XOR process is the same as that (1701) between the selectable permutation E process result and the cipher key.

[0142] In DES, the IP^{-1} process (915) is executed at the last stage. This process is illustrated in Fig. 21. The IP-1 process is a bit position exchange process similar to the IP process, and uses an IP-1 table instead of the IP table (2102). The process result obtained by the above-described processes is subjected to the IP-1 process, and the disturbance data X is also subjected to the IP-1 process (2103).

[0143] Lastly, in order to recover the correct process result, the untransforming process is executed (916) which is illustrated in Fig. 22. An XOR between the IP-1 process result and the IP-1 processed disturbance data X generates a correct result. The correct process result not transformed can be obtained at the first time at this stage.

[0144] To conceal the process data has been described above. There is the case that the disturbance data is also required to be concealed. The fundamental concept is to transform the disturbance data through an exclusive logical OR between the disturbance data and disturbance data XR for disturbance. In this case, XR is fixed and XRo for the untransformation is obtained in advance by calculating bit position exchange or the like. When the disturbance data becomes necessary, the original disturbance data is obtained by using XRo. First, this process will be described by taking disturbance data for the cipher key as an example. The process illustrated in Fig. 30 is a disturbance data transforming process through an exclusive logical OR between the disturbance data for a cipher key and the disturbance data XR for disturbance. After the transforming process b (3601) generates the disturbance data X2, the disturbance data transforming process shown in Fig. 30 is executed. The disturbance data X2 for the cipher key is subjected to the PC-1 process, LS process and PC-2 process. These processes perform the bit exchange at predetermined bit positions. Therefore, for the predetermined value XR, the disturbance data XRo subjected to the processes up to the PC-2 process is calculated and stored in advance (3102 to 3105). After the PC-2 process, an XOR is calculated (3202) between the PC-1, LS, PC-2 processed disturbance data X2PC1LSPC2 generated at 1403 and the stored disturbance data XRo can generate correct PC-1, LS, PC-2 processed disturbance data X2PC1LSPC2. With these processes, the disturbance data can also be concealed. The same data may be used as the disturbance data XR for disturbance and as the processed, disturbance transformed data XRo.

[0145] The embodiments for DES are related to encryption. Since nearly the same DES algorithm is used also for decryption, the embodiments can be applied also to decryption, by hardly modifying the embodiments. Cryptographic algorithms other than DES use many permutation processes, substitution processes and modular calculations. Therefore, the invention can be applied to such algorithms to make it difficult to alter data and presume original data through observation of current wave shapes.

[0146] According to the present invention, data to be processed by an IC card chip is transformed so that it is difficult to presume processes and a cipher key through observation of current wave shapes.

Claims

1. An information processing equipment comprising

   a storage memory including a program storage unit and a data storage unit,

   a central processing unit for executing a data process in accordance with the program, the program including one or more data process means each being a process instruction for giving an execution instruction to said central processing unit, and

   input data processing means wherein one data processing means processes input data and outputs the processed data,

   characterised by

   data transforming process means (406) for transforming input data D1 by using disturbance data Xi to generate transformed data H1,

   transformed data processing means (408) for executing an operation process OP1 for the transformed data H1 in place of the operation process OP1 for the input data D1 to be executed by said input data processing means, to generate processed and transformed data H2,

   disturbance data processing means (403) for executing the operation process OP1 for the disturbance data Xi to generate processed disturbance data Xo, and

   data untransforming processing means (410) for executing an operation process OP2 for the processed and transformed data H2 by using the processed disturbance data Xo, to generate processed data D2 which is a result of the operation process OP1 for the input data D1.

2. An information processing equipment comprising

   a storage memory including a program storage unit and a data storage unit, and

   a central processing unit for executing a data process in accordance with the program, the program including one or more data process means,

   characterised by

   means (506) for executing a predetermined

   operation process OP1 for first input data D1 by using first disturbance data X1i to generate transformed data H1 of the first input data D1, without executing the operation process OP1 for the first input data D1 to generate first processed data D2,

   means (508) for executing the operation process OP1 or another operation process OP1' different from the operation process OP1 for the transformed data H1 to generate processed and transformed data H2,

   means (503) for executing either the operation process OP1 or the other operation process OP1' for the first disturbance data X1i to generate first processed disturbance data X1o,

   means (510) for generating processed and transformed data H3 by transforming the processed and transformed data H2 by using second disturbance data X2i,

   means (512) for executing either the operation process OP1 or the other operation process OP1' for the processed and transformed data H3 to generate processed and transformed data H4,

   means (518) for executing either the operation process OP1 or the other operation process OP1' for the second disturbance data X2i to generate second processed disturbance data X2o,

   means (520) for processing the processed and transformed data H4 by using the second processed disturbance data X2o to generate processed and transformed data H5, and

   means (514) for processing the processed and transformed data H5 by using the first processed disturbance data X1o to generate the first processed data D2.

3. An information processing equipment comprising

   a storage memory including a program storage unit and a data storage unit, and

   a central processing unit for executing a data process in accordance with the program, the program including one or more data process means,

   characterised by

   means (607) for executing a predetermined

   operation process OP1 for first input data D1 by using first disturbance data X1i to generate transformed data H1 of the first input data D1, without executing the operation process OP1 for the first input data D1 to generate first processed data D3,

   means (610) for executing the operation process OP1 or another operation process OP1' different from the operation process OP1 for the transformed data H1 to generate processed and transformed data H2,

   means (603) for executing either the operation process OP1 or the other operation process OP1' for the first disturbance data X1i to generate first processed disturbance data X1o, means (612) for generating processed and transformed data H3 by transforming the processed and transformed data H2 by using second disturbance data X2i,

means (605) for executing an untransforming process for the processed and transformed data H3 by using the first processed disturbance data X1o to generate processed and transformed data H4,

means (614) for executing either a predetermined operation process OP2 or another operation process OP2' different from the operation process OP2 for the processed and transformed data H4 to generate processed and transformed data H5, without executing the operation process OP2 for the first processed data D3 to generate the first and second processed data D2,

means (620) for executing either the operation process OP2 or the other operation process OP2' for the second disturbance data X2i to generate second processed disturbance data X2o, and

means (616) for processing the processed and transformed data H5 by using the second processed disturbance data X2o to generate the processed data D2.

4. An information processing equipment **characterised by**

means (812) for executing a predetermined operation process OP1 for first input data D1 by using first disturbance data X1i to generate transformed data H1 of the first input data D1, without executing the operation process OP1 for the first input data D1 to generate first processed data D3,

means (814) for executing the operation process OP1 or another operation process OP1' different from the operation process OP1 for the transformed data H1 to generate processed and transformed data H2,

means (803) for executing either the operation process OP1 or the other operation process OP1' for the first disturbance data X1i to generate first processed disturbance data X1o,

means (816) for generating processed and transformed data H3 by transforming the processed and transformed data H2 by using second disturbance data X2i,

means (818) for executing an untransforming process for the processed and transformed data H3 by using the first processed disturbance data X1o to generate processed and transformed data H4,

means for executing either a predetermined operation process OP2 or another operation process OP2' different from the operation process OP2 for the processed and transformed data H4 to generate processed and transformed data H5, without executing the operation process OP2 for the first processed data D3 to generate the first and second processed data D2,

means (807) for executing either the operation process OP2 or the other operation process OP2' for the second disturbance data X2i to generate second processed disturbance data X2o,

means (809) for generating unified disturbance data Xo by unifying the first and second processed disturbance data X1o and X2o, and

means (820) for executing an untransforming process for the processed and transformed data H4 by using the unified disturbance data Xo to generate the processed data D2.

5. The equipment of claim 1, further comprising

means (704) for storing the processed disturbance data Xo, and

means (713) for processing the processed and transformed data by using the stored, processed disturbance data Xo to generate new processed, transformed data.

6. The equipment of any preceding claim, wherein the disturbance data is generated by using a random number.

7. The equipment of claim 1, wherein

the data transforming process is (a) an exclusive logical OR process, or (b) an addition operation, or (c) a subtraction operation, or (d) a multiplication operation, or (e) a division operation between the disturbance data Xi and the input data D1, and

the data untransforming process is (a) an exclusive logical OR process, or (b) a subtraction operation, or (c) an addition operation, or (d) a division operation, or (e) a multiplication operation between the processed disturbance data Xo and the processed and transformed data H2.

8. The equipment of claim 1, wherein, if the input data process includes an addition/subtraction process in a modular calculation, the data transforming process uses an addition/subtraction of a number multiplying a modulus N by an arbitrary integer.

9. The equipment of claim 1, wherein, if the input data process includes a multiplication process in a modular calculation and numbers X and Y satisfy 1 = X * Y mod N,

(a) X is multiplied by an integer in the modular calculation of the data transforming process, and
Y is multiplied by an integer by the number of times said data transforming processing means multiplied X, or
(b) (N+1)/2 is multiplied by an integer in the modular calculation of the data transforming process, by using N as a modulus of the modular calculation, and
2 is multiplied by an integer by the number of times said data transforming processing means multiplied (N+1) /2, in the data untransforming process, or
(c) 2 is multiplied by an integer in the modular calculation of the data transforming process, and
(N+1)/2 is multiplied by an integer by the number of times said data transforming processing means multiplied 2, in the data untransforming process, by using N as a modulus of the modular calculation.

10. The equipment of claim 1, wherein the data transforming process regularly changes positions of array data, and the data untransforming process accesses the array data changed by the data transforming process.

11. The equipment of claim 10, wherein the positions of the array data are regularly changed through an exclusive logical OR between an index (argument) of the array data and a certain number, an exclusive logical OR between the index of the array data and the number used by the data transforming process is used as an index of the transformed data array, and the data untransforming process accesses the array data in accordance with the transformed index.

12. The equipment of claim 1, wherein the operation process OP1 is (a) a permutation process of exchanging data on a one-bit unit basis, or (b) a substitution process of exchanging data on a one-bit unit basis, or (c) a process of exchanging data by using a table, and the data transforming process and the data untransforming process are an exclusive logical OR process for the data.

13. An information processing equipment, comprising a processing unit for processing input data in accordance with a computer program and outputting the processed data, **characterised by**

means (709) for transforming input data D1 by using disturbance data Xi to generate transformed data H1, without executing a predetermined operation process OP1 for the input data D1 to generate processed data D2,

means (712) for executing the operation process OP1 or another operation process OP1' different from the operation process OP1 for the transformed data H1 to generate processed and transformed data H2,

means (701) for executing either the operation process OP1 or the other operation process OP1' for the disturbance data Xi to generate processed disturbance data Xo, and

means (713) for executing a data untransforming process OP2 for the processed and transformed data H2 by using the processed disturbance data Xo to generate the processed data D2 as a result of the operation process OP1 for the input data D1.

Patentansprüche

1. Informationsverarbeitungseinrichtung mit

einem Speicher mit einer Programmspeichereinheit und einer Datenspeichereinheit,

einer Zentralverarbeitungseinheit zum Ausführen eines Datenprozesses entsprechend dem Programm, wobei das Programm ein oder mehrere Datenverarbeitungseinrichtungen aufweist, deren jede ein Prozeßbefehl ist, um der Zentralverarbeitungseinheit einen Ausführungsbefehl zu erteilen, und

einer Eingabedaten-Verarbeitungseinrichtung, wobei eine Datenverarbeitungseinrichtung Eingabedaten verarbeitet und die verarbeiteten Daten ausgibt,

gekennzeichnet durch

eine Daten umwandelnde Verarbeitungseinrichtung (406) zum Umwandeln von Eingabedaten D1 unter Verwendung von Stördaten Xi zur Erzeugung umgewandelter Daten H1,

eine umgewandelte Daten verarbeitende Einrichtung (408) zum Ausführen eines Operationsprozesses OP1 an den umgewandelten Daten H1 anstelle des von der Eingabedaten-Verarbeitungseinrichtung auszuführenden Operationsprozesses OP1 für die Eingabedaten D1, um verarbeitete und umgewandelte Daten H2 zu erzeugen,

eine Stördaten-Verarbeitungseinrichtung (403) zum Ausführen des Operationsprozesses OP1 an den Stördaten Xi zur Erzeugung verarbeiteter Stördaten Xo und

eine Datenrückwandlungseinrichtung (410) zum Ausführen eines Operationsprozesses OP2 an den verarbeiteten und umgewandelten Daten H2 unter Verwendung der verarbeiteten Stördaten Xo zur Erzeugung verarbeiteter Daten D2 als Ergebnis des Operationsprozesses OP1 an den Eingabedaten D1.

2. Informationsverarbeitungseinrichtung mit

einem Speicher mit einer Programmspeichereinheit und einer Datenspeichereinheit und

einer Zentralverarbeitungseinheit zum Ausführen eines Datenprozesses entsprechend dem Programm, wobei das Programm ein oder mehrere Datenverarbeitungseinrichtungen enthält,

gekennzeichnet durch

eine Einrichtung (506) zum Ausführen eines vorgegebenen Operationsprozesses OP1 an ersten Eingabedaten D1 unter Verwendung erster Stördaten X1i zur Erzeugung umgewandelter Daten H1 der ersten Eingabedaten D1, ohne Ausführung des Operationsprozesses OP1 an den ersten Eingabedaten D1 zur Erzeugung erster verarbeiteter Daten D2,

eine Einrichtung (508) zum Ausführen des Verarbeitungsprozesses OP1 oder eines von diesem verschiedenen weiteren Operationsprozesses OP1' an den umgewandelten Daten H1 zur Erzeugung verarbeiteter und umgewandelter Daten H2,

eine Einrichtung (503) zum Ausführen entweder des Operationsprozesses OP1 oder des weiteren Operationsprozesses OP1' an den ersten Stördaten X1i zur Erzeugung erster verarbeiteter Stördaten X1o,

eine Einrichtung (510) zum Erzeugen verarbeiteter und umgewandelter Daten H3 **durch** Umwandeln der verarbeiteten und umgewandelten Daten H2 unter Verwendung zweiter Stördaten X2i,

eine Einrichtung (512) zum Ausführen entweder des Operationsprozesses OP1 oder des weiteren Operationsprozesses OP1' an den verarbeiteten und umgewandelten Daten H3 zur Erzeugung verarbeiteter und umgewandelter Daten H4,

eine Einrichtung (518) zum Ausführen entweder des Operationsprozesses OP1 oder des weiteren Operationsprozesses OP1' an den zweiten Stördaten X2i zur Erzeugung zweiter verarbeiteter Stördaten X2o,

eine Einrichtung (520) zum Verarbeiten der verarbeiteten und umgewandelten Daten H4 unter Verwendung der zweiten verarbeiteten Stördaten X2o zur Erzeugung verarbeiteter und umgewandelter Daten H5, und

eine Einrichtung (514) zum Verarbeiten der verarbeiteten und umgewandelten Daten H5 unter Verwendung der ersten verarbeiteten Stördaten X1o zur Erzeugung der ersten verarbeiteten Daten D2.

3. Informationsverarbeitungseinrichtung mit

einem Speicher mit einer Programmspeichereinheit und einer Datenspeichereinheit und

einer Zentralverarbeitungseinheit zum Ausführen eines Datenprozesses entsprechend dem Programm, wobei das Programm ein oder mehrere Datenverarbeitungseinrichtungen enthält,

gekennzeichnet durch

eine Einrichtung (607) zum Ausführen eines vorgegebenen Operationsprozesses OP1 an ersten Eingabedaten D1 unter Verwendung erster Stördaten X1i zur Erzeugung umgewandelter Daten H1 der ersten Eingabedaten D1, ohne Ausführung des Operationsprozesses OP1 an den ersten Eingabedaten D1 zur Erzeugung erster verarbeiteter Daten D3,

eine Einrichtung (610) zum Ausführen des Operationsprozesses OP1 oder eines von diesem verschiedenen Operationsprozesses OP1' an den umgewandelten Daten H1 zur Erzeugung verarbeiteter und umgewandelter Daten H2,

eine Einrichtung (603) zum Ausführen entweder des Operationsprozesses OP1 oder des weiteren Operationsprozesses OP1' an den ersten Stördaten X1i zur Erzeugung erster verarbeiteter Stördaten X1o,

eine Einrichtung (610) zum Erzeugen verarbeiteter und umgewandelter Daten H3 **durch** Umwandeln der verarbeiteten und umgewandelten Daten H2 unter Verwendung zweiter Stördaten X2i,

eine Einrichtung (605) zum Ausführen eines Rückwandlungsprozesses an den verarbeiteten und umgewandelten Daten H3 unter Verwendung der ersten verarbeiteten Stördaten X1o zur Erzeugung verarbeiteter und umgewandelter Daten H4,

eine Einrichtung (614) zum Ausführen entweder eines vorgegebenen Operationsprozesses OP2 oder eines von diesem verschiedenen weiteren Operationsprozesses OP2' an den verarbeiteten und umgewandelten Daten H4 zur Erzeugung verarbeiteter und umgewandelter Daten H5, ohne Ausführung des Operationsprozesses OP2 an den ersten verarbeiteten Daten D3 zur Erzeugung der ersten und der zweiten verarbeiteten Daten D2,

eine Einrichtung (620) zum Ausführen entweder des Operationsprozesses OP2 oder des weiteren Operationsprozesses OP2' an den zweiten Stördaten X2i zur Erzeugung zweiter verarbeiteter Stördaten X2o, und

eine Einrichtung (616) zum Verarbeiten der verarbeiteten und umgewandelten Daten H2 unter Verwendung der zweiten verarbeiteten Stördaten X2o zur Erzeugung der verarbeiteten Daten D2.

4. Informationsverarbeitungseinrichtung, **gekennzeichnet durch**

eine Einrichtung (812) zum Ausführen eines vorgegebenen Operationsprozesses OP1 an ersten Eingabedaten D1 unter Verwendung erster Stördaten X1i zur Erzeugung umgewandelter Daten H1 der ersten Eingabedaten D1, ohne Ausführung des Operationsprozesses OP1 an den ersten Eingabedaten D1 zur Erzeugung erster verarbeiteter Daten D3,

eine Einrichtung (814) zum Ausführen des Operationsprozesses OP1 oder eines von diesem verschiedenen weiteren Operationsprozesses OP1' an den umgewandelten Daten H1 zur Erzeugung verarbeiteter und umgewandelter Daten H2,

eine Einrichtung (803) zum Ausführen entweder des Operationsprozesses OP1 oder des weiteren Operationsprozesses OP1' an den ersten Stördaten X1i zur Erzeugung erster verarbeiteter Stördaten X1o,

eine Einrichtung (816) zum Erzeugen verarbeiteter und umgewandelter Daten H3 **durch** Umwandeln der verarbeiteten und umgewandelten Daten H2 unter Verwendung zweiter Stördaten X2i,

eine Einrichtung (818) zum Ausführen eines Rückwandlungsprozesses an den verarbeiteten und umgewandelten Daten H3 unter Verwendung der ersten verarbeiteten Stördaten X1o zur Erzeugung verarbeiteter und umgewandelter Daten H4,

eine Einrichtung zum Ausführen entweder eines vorgegebenen Operationsprozesses OP2 oder eines von diesem verschiedenen weiteren Operationsprozesses OP2' an den verarbeiteten und umgewandelten Daten H4 zur Erzeugung verarbeiteter und umgewandelter Daten H5, ohne Ausführung des Operationsprozesses OP2 an den ersten verarbeiteten Daten D3 zur Erzeugung der ersten und der zweiten verarbeiteten Daten D2,

eine Einrichtung (807) zum Ausführen entweder des Operationsprozesses OP2 oder des weiteren Operationsprozesses OP2' an den zweiten Stördaten X2i zur Erzeugung zweiter verarbeiteter Stördaten X2o,

eine Einrichtung (809) zum Erzeugen einheitlicher Stördaten Xo **durch** Vereinheitlichen der ersten und der zweiten verarbeiteten Stördaten X1o und X2o, und

eine Einrichtung (820) zum Ausführen eines Rückwandlungsprozesses an den verarbeiteten und umgewandelten Daten H4 unter Verwendung der einheitlichen Stördaten Xo zur Erzeugung der verarbeiteten Daten D2.

5. Einrichtung nach Anspruch 1 mit ferner

einer Einrichtung (704) zum Speichern der verarbeiteten Stördaten Xo, und

einer Einrichtung (713) zum Verarbeiten der verarbeiteten und umgewandelten Daten unter Verwendung der gespeicherten verarbeiteten Stördaten Xo zur Erzeugung neuer verarbeiteter umgewandelter Daten.

6. Einrichtung nach einem der vorhergehenden Ansprüche, wobei die Stördaten unter Verwendung einer Zufallszahl erzeugt werden.

7. Einrichtung nach Anspruch 1, wobei

der Datenumwandlungsprozeß (a) ein logischer Exklusiv-ODER-Prozeß oder (b) ein Addierprozeß oder (c) ein Subtraktionsprozeß oder (d) ein Multiplikationsprozeß oder (e) ein Divisionsprozeß zwischen den Stördaten Xi und den Eingabedaten D1 ist und

der Datenrückwandlungsprozeß (a) ein logischer Exklusiv-ODER-Prozeß oder (b) ein Subtraktionsprozeß oder (c) ein Additionsprozeß oder (d) ein Divisionsprozeß oder (e) ein Multiplikationsprozeß zwischen den verarbeiteten Stördaten Xo und den verarbeiteten und umgewandelten Daten H2 ist.

8. Einrichtung nach Anspruch 1, wobei dann, wenn der Eingabedatenprozeß einen Additions/Subtraktionsprozeß in einer Modularrechnung enthält, der Datenumwandlungsprozeß mit einer Addition/Subtraktion einer Zahl arbeitet, die einen Modulus N mit einer beliebigen ganzen Zahl multipliziert.

9. Einrichtung nach Anspruch 1, wobei dann, wenn der Eingabedatenprozeß einen Multiplikationsprozeß in einer Modularrechnung enthält und die Zahlen X und Y die Bedingung 1 = X * Y mod N erfüllen,

(a) X in der Modularrechnung des Datenumwandlungsprozesses mit einer ganzen Zahl und
Y mit einer ganzen Zahl multipliziert wird, sooft die Daten umwandelnde Verarbeitungseinrichtung mit X multipliziert, oder
(b) (N+1)/2 in der Modularrechnung des Datenumwandlungsprozesses mit einer ganzen Zahl multipliziert wird, wobei N als Modulus der Modularrechnung benutzt wird und
2 mit einer ganzen Zahl multipliziert wird, sooft die Daten umwandelnde Verarbeitungseinrichtung in dem Datenrückwandlungsprozeß mit (N+1)/2 multipliziert, oder
(c) 2 in der Modularrechnung des Daten umwandelnden Prozesses mit einer
ganzen Zahl multipliziert wird und
(N+1)/2 mit einer ganzen Zahl multipliziert wird, sooft die Daten umwandelnde Verarbeitungseinrichtung in dem Datenrückwandlungsprozeß mit 2 multipliziert, wobei N als Modulus der Modularrechnung benutzt wird.

10. Einrichtung nach Anspruch 1, wobei der Datenumwandlungsprozeß Positionen von Arraydaten regelmäßig ändert und der Datenrückwandlungsprozeß auf die durch den Datenumwandlungsprozeß geänderten Arraydaten zugreift.

11. Einrichtung nach Anspruch 10, wobei die Positionen der Arraydaten durch ein logisches Exklusiv-ODER zwischen einem Index (Argument) der Arraydaten und einer bestimmten Zahl regelmäßig geändert werden, ein logisches Exklusiv-ODER zwischen dem Index der Arraydaten und der von dem Datenumwandlungsprozeß benutzten Zahl als Index des umgewandelten Datenarrays verwendet wird, und der Datenrückwandlungsprozeß entsprechend dem umgewandelten Index auf die Arraydaten zugreift.

12. Einrichtung nach Anspruch 1, wobei der Operationsprozeß OP1 (a) ein datentauschender Permutationsprozeß auf der Basis einer 1-Bit-Einheit oder (b) ein datentauschender Substitutionsprozeß auf der Basis einer 1-Bit-Einheit oder (c) ein Datentauschprozeß unter Verwendung einer Tabelle ist, und wobei der Datenumwandlungsprozeß und der Datenrückwandlungsprozeß ein logischer Exklusiv-ODER-Prozeß an den Daten ist.

13. Informationsverarbeitungseinrichtung mit einer Verarbeitungseinheit zum Verarbeiten von Eingabedaten entsprechend einem Computerprogramm und zur Ausgabe der verarbeiteten Daten, **gekennzeichnet durch**

eine Einrichtung (709) zum Umwandeln von Eingabedaten D1 unter Verwendung von Stördaten Xi zur Erzeugung umgewandelter Daten H1, ohne Ausführung eines vorgegebenen Operationsprozesses OP1 an den Eingabedaten D1 zur Erzeugung verarbeiteter Daten D2,

eine Einrichtung (712) zum Ausführen des Operationsprozesses OP1 oder eines von diesem verschiedenen weiteren Operationsprozesses OP1' an den umgewandelten Daten H1 zur Erzeugung verarbeiteter und umgewandelter Daten H2,

eine Einrichtung (701) zum Ausführen entweder des Operationsprozesses OP1 oder des weiteren Operationsprozesses OP1' an den Stördaten Xi zur Erzeugung verarbeiteter Stördaten Xo und

eine Einrichtung (713) zum Ausführen eines Datenrückwandlungsprozesses OP2 an den verarbeiteten und umgewandelten Daten H2 unter Verwendung der verarbeiteten Stördaten Xo zur Erzeugung der verarbeiteten Daten D2 als Resultat des Operationsprozesses OP1 an den Eingabedaten D1.

Revendications

1. Equipement de traitement d'informations comportant :

une mémoire de stockage incluant une unité de mémorisation de programme et une unité de mémorisation de données,
une unité centrale de traitement pour exécuter un traitement de données conformément au programme, le programme incluant un ou plusieurs moyens de traitement de données, chacun étant une instruction de traitement destinée à donner une instruction d'exécution à ladite unité centrale de traitement, et
des moyens de traitement de données d'entrée dans lesquels un moyen de traitement de données traite des données d'entrée et délivre en sortie des données traitées,

caractérisé par

des moyens de traitement de transformation de données (406) pour transformer des données d'entrée D1 en utilisant des données de perturbation Xi en vue de générer des données transformées H1,

des moyens de traitement de données transformées (408) pour exécuter un traitement d'opération OP1 pour les données transformées H1 à la place du traitement d'opération OP1 pour les données d'entrée D1 à exécuter par lesdits moyens de traitement de données d'entrée, en vue de générer des données traitées et transformées H2,

des moyens de traitement de données de perturbation (403) pour exécuter un traitement d'opération OP1 pour les données de perturbation Xi en vue de générer des données de perturbation traitées Xo, et

des moyens de traitement de non-transformation de données (410) pour exécuter un traitement d'opération OP2 pour les données traitées et transformées H2 en utilisant les données de perturbation traitées Xo, en vue de générer des données traitées D2 qui sont un résultat du traitement d'opération OP1 des données d'entrée D1.

2. Equipement de traitement d'informations comportant :

une mémoire de stockage incluant une unité de mémorisation de programme et une unité de mémorisation de données, et
une unité centrale de traitement pour exécuter un traitement de données conformément au programme, le

programme incluant un ou plusieurs moyens de traitement de données,

caractérisé par
des moyens (506) pour exécuter un traitement d'opération prédéterminé OP1 pour des premières données d'entrée D1 en utilisant des premières données de perturbation X1i pour générer des données transformées H1 des premières données d'entrée D1, sans exécuter le traitement d'opération OP1 pour les premières données d'entrée D1 pour générer des premières données traitées D2,
des moyens (508) pour exécuter le traitement d'opération OP1 ou un autre traitement d'opération OP1' différent du traitement d'opération OP1 relatif aux données transformées H1 en vue de générer des données traitées et transformées H2,
des moyens (503) pour exécuter le traitement d'opération OP1 ou l'autre traitement d'opération OP1' pour les premières données de perturbation X1i en vue de générer des premières données de perturbation traitées X1o,
des moyens (510) pour générer des données traitées et transformées H3 en transformant les données traitées et transformées H2 en utilisant des secondes données de perturbation X2i,
des moyens (512) pour exécuter le traitement d'opération OP1 ou l'autre traitement d'opération OP1' pour les données traitées et transformées H3 en vue de générer des données traitées et transformées H4,
des moyens (518) pour exécuter le traitement d'opération OP1 ou l'autre traitement d'opération OP1' pour les secondes données de perturbation X2i en vue de générer des secondes données de perturbation traitées X2o,
des moyens (520) pour traiter les données traitées et transformées H4 en utilisant les secondes données de perturbation traitées X2o en vue de générer des données traitées et transformées H5, et
des moyens (514) pour traiter les données traitées et transformées H5 en utilisant les premières données de perturbation traitées X1o en vue de générer les premières données traitées D2.

3. Equipement de traitement d'informations comportant :

une mémoire de stockage incluant une unité de mémorisation de programme et une unité de mémorisation de données, et
une unité centrale de traitement pour exécuter un traitement de données conformément au programme, le programme incluant un ou plusieurs moyens de traitement de données,

caractérisé par
des moyens (607) pour exécuter un traitement d'opération prédéterminé OP1 pour des premières données d'entrée D1 en utilisant des premières données de perturbation X1i en vue de générer des données transformées H1 des premières données d'entrée D1, sans exécuter le traitement d'opération OP1 pour les premières données d'entrée D1 pour générer des premières données traitées D3,
des moyens (610) pour exécuter le traitement d'opération OP1 ou l'autre traitement d'opération OP1' différent du traitement d'opération OP1 relatif aux données transformées H1 en vue de générer des données traitées et transformées H2,
des moyens (603) pour exécuter le traitement d'opération OP1 ou l'autre traitement d'opération OP1' pour les premières données de perturbation X1i en vue de générer des premières données de perturbation traitées X1o,
des moyens (612) pour générer des données traitées et transformées H3 en transformant les données traitées et transformées H2 en utilisant des secondes données de perturbation X2i,
des moyens (605) pour exécuter un traitement de non-transformation des données traitées et transformées H3 en utilisant les premières données de perturbation traitées X1o en vue de générer des données traitées et transformées H4,
des moyens (614) pour exécuter un traitement d'opération prédéterminé OP2 ou un autre traitement d'opération OP2' différent du traitement d'opération OP2 pour les données traitées et transformées H4 en vue de générer des données traitées et transformées H5, sans exécuter le traitement d'opération OP2 pour les premières données traitées D3 en vue de générer les premières et secondes données traitées D2,
des moyens (620) pour exécuter le traitement d'opération OP2 ou l'autre traitement d'opération OP2' pour les secondes données de perturbation X2i en vue de générer des secondes données de perturbation traitées X2o, et
des moyens (616) pour traiter les données traitées et transformées H5 en utilisant les secondes données de perturbation traitées X2o en vue de générer les données traitées D2.

4. Equipement de traitement d'informations **caractérisé par**
des moyens (812) pour exécuter un traitement d'opération prédéterminé OP1 pour les premières données d'entrée D1 en utilisant des premières données de perturbation X1i en vue de générer des données transformées

H1 des premières données d'entrée D1, sans exécuter le traitement d'opération OP1 pour les premières données d'entrée D1 en vue de générer des premières données traitées D3,

des moyens (814) pour exécuter le traitement d'opération OP1 ou un autre traitement d'opération OP1' différent du traitement d'opération OP1 pour les données transformées H1 en vue de générer des données traitées et transformées H2,

des moyens (803) pour exécuter le traitement d'opération OP1 ou l'autre traitement d'opération OP1' pour les premières données de perturbation X1i en vue de générer des premières données de perturbation traitées X1o,

des moyens (816) pour générer des données traitées et transformées H3 en transformant les données traitées et transformées H2 en utilisant des secondes données de perturbation X2i,

des moyens (818) pour exécuter un traitement de non-transformation pour les données traitées et transformées H3 en utilisant les premières données de perturbation traitées X1o en vue de générer des données traitées et transformées H4,

des moyens pour exécuter un traitement d'opération prédéterminé OP2 ou un autre traitement d'opération OP2' différent du traitement d'opération OP2 pour les données traitées et transformées H4 en vue de générer des données traitées et transformées H5, sans exécuter le traitement d'opération OP2 pour les premières données traitées D3 en vue de générer les premières et secondes données traitées D2,

des moyens (807) pour exécuter le traitement d'opération OP2 ou l'autre traitement d'opération OP2' pour les secondes données de perturbation X2i en vue de générer des secondes données de perturbation traitées X2o,

des moyens (809) pour générer des données de perturbation unifiées Xo en unifiant les premières et secondes données de perturbation traitées X1o et X2o, et

des moyens (820) pour exécuter un traitement de non-transformation pour les données traitées et transformées H4 en utilisant les données de perturbation unifiées Xo en vue de générer les données traitées D2.

5. Equipement selon la revendication 1, comportant en outre

des moyens (704) pour mémoriser les données de perturbation traitées Xo, et

des moyens (713) pour traiter les données traitées et transformées en utilisent les données de perturbation mémorisées et traitées Xo en vue de générer de nouvelles données traitées et transformées.

6. Equipement selon l'une quelconque des revendications précédentes, dans lequel les données de perturbation sont générées en utilisant un nombre aléatoire.

7. Equipement selon la revendication 1, dans lequel

le traitement de transformation de données est (a) un traitement OU-exclusif logique, ou (b) une opération d'addition, ou (c) une opération de soustraction, ou (d) une opération de multiplication, ou (e) une opération de division entre les données de perturbation Xi et les données d'entrée D1, et

le traitement de non-transformation de données est (a) un traitement OU-exclusif logique, ou (b) une opération de soustraction, ou (c) une opération d'addition, ou (d) une opération de division, ou (e) une opération de multiplication entre les données de perturbation traitées Xo et les données traitées et transformées H2.

8. Equipement selon la revendication 1, dans lequel, si le traitement de données d'entrée inclut un traitement d'addition/soustraction dans un calcul modulaire, le traitement de transformation de données utilise une addition/soustraction d'un nombre multipliant un modulo N par un nombre entier arbitraire.

9. Equipement selon la revendication 1, dans lequel, si le traitement de données d'entrée inclut un traitement de multiplication dans un calcul modulaire et des nombres X et Y satisfont 1 = X * Y mod N,

(a) X est multiplié par un nombre entier dans le calcul modulaire du traitement de transformation de données, et Y est multiplié par un nombre entier par le nombre de fois que lesdits moyens de traitement de transformation de données ont multiplié X, ou

(b) (N+1)/2 est multiplié par un nombre entier dans le calcul modulaire du traitement de transformation de données, en utilisant N comme un modulo du calcul modulaire, et
2 est multiplié par un nombre entier par le nombre de fois que lesdits moyens de traitement de transformation de données ont multiplié (N+1)/2, dans le traitement de non-transformation de données, ou

(c) 2 est multiplié par un nombre entier dans le calcul modulaire du traitement de transformation de données, et (N+1)/2 est multiplié par un nombre entier par le nombre de fois que lesdits moyens de traitement de transformation de données ont multiplié 2, dans le traitement de transformation de données, en utilisant N comme un modulo du calcul modulaire.

10. Equipement selon la revendication 1, dans lequel le traitement de transformation de données change régulièrement les positions des données de tableau, et le traitement de non-transformation de données accède aux données de tableau changées par le traitement de transformation de données.

11. Equipement selon la revendication 10, dans lequel les positions des données de tableau sont régulièrement changées par l'intermédiaire d'un OU-exclusif logique entre un indice (argument) des données de tableau et un certain nombre, un OU-exclusif logique entre l'indice des données de tableau et le nombre utilisé par le traitement de transformation de données est utilisé en tant qu'indice du tableau de données transformées, et le traitement de transformation de données accède aux données de tableau conformément à l'indice transformé.

12. Equipement selon la revendication 1, dans lequel le traitement d'opération OP1 est (a) un traitement de permutation de données d'échange sur une base d'unité à un bit, ou (2) un traitement de substitution de données d'échange sur une base d'unité à un bit, ou (c) un traitement d'échange de données en utilisant un tableau, et le traitement de transformation de données et le traitement de non-transformation de données sont un traitement OU-exclusif logique des données.

13. Equipement de traitement d'informations, comportant une unité de traitement pour traiter des données d'entrée conformément à un programme informatique et délivrer en sortie les données traitées, **caractérisé par**

des moyens (709) pour transformer des données d'entrée D1 en utilisant des données de perturbation Xi en vue de générer des données transformées X1, sans exécuter un traitement d'opération prédéterminé OP1 pour les données d'entrée D1 en vue de générer les données traitées D2,

des moyens (712) pour exécuter le traitement d'opération OP1 ou un autre traitement d'opération OP1' différent du traitement d'opération OP1 pour les données transformées H1 en vue de générer des données traitées et transformées H2,

des moyens, (701) pour exécuter le traitement d'opération OP1 ou l'autre traitement d'opération OP1' pour les données de perturbation Xi en vue de générer des données de perturbation traitées Xo, et

des moyens (713) pour exécuter un traitement de non-transformation de données OP2 pour les données traitées et transformées H2 en utilisant les données de perturbation traitées Xo en vue de générer les données traitées D2 en résultat du traitement d'opération OP1 pour les données D1.

FIG. 1

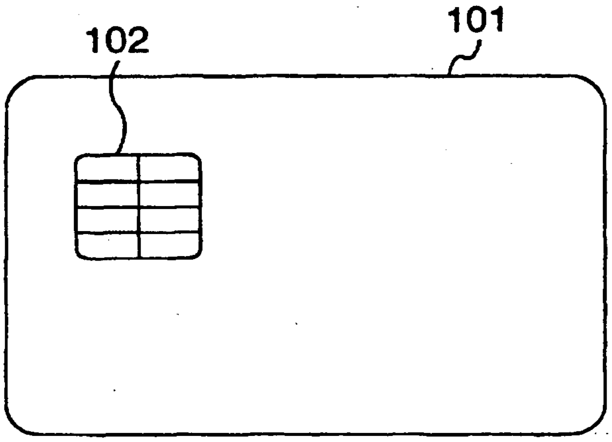

102
101

FIG. 2

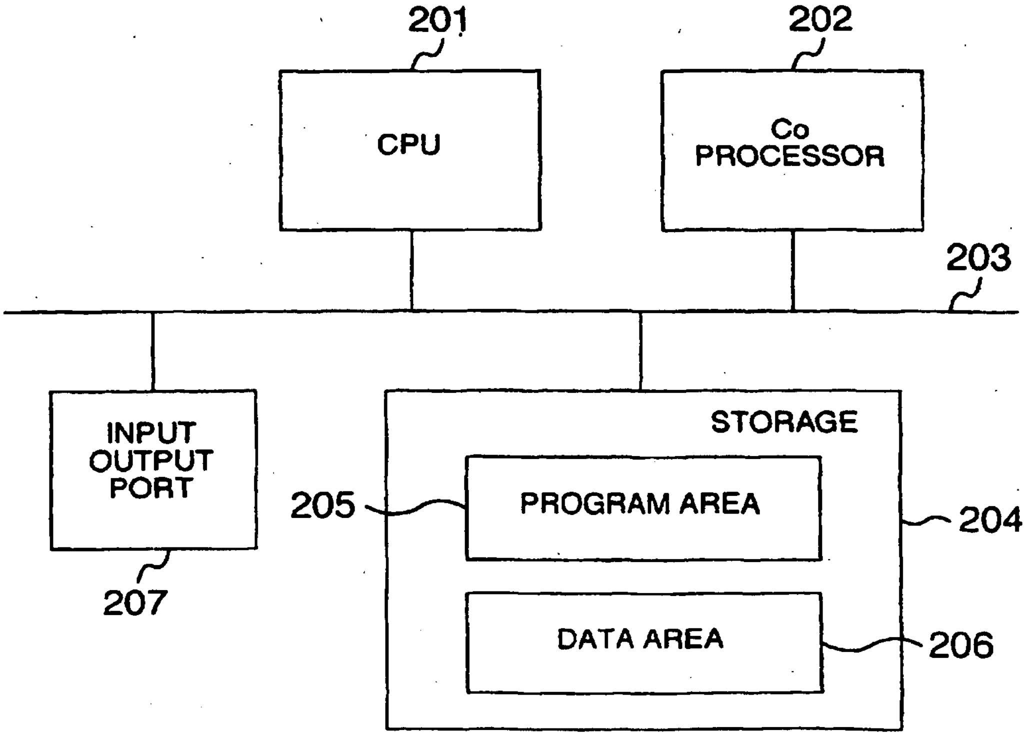

201
202
CPU
Co PROCESSOR
203
INPUT OUTPUT PORT
STORAGE
PROGRAM AREA
DATA AREA
205
204
207
206

FIG. 3

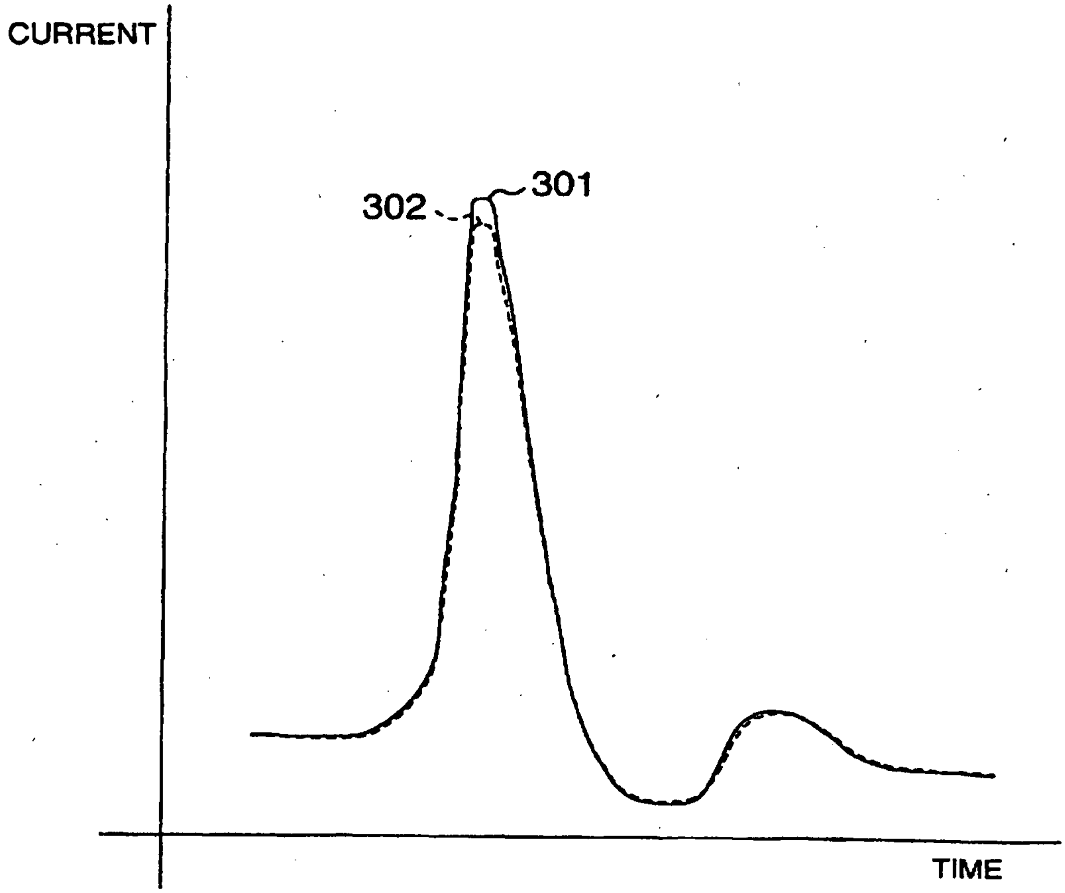


FIG. 4

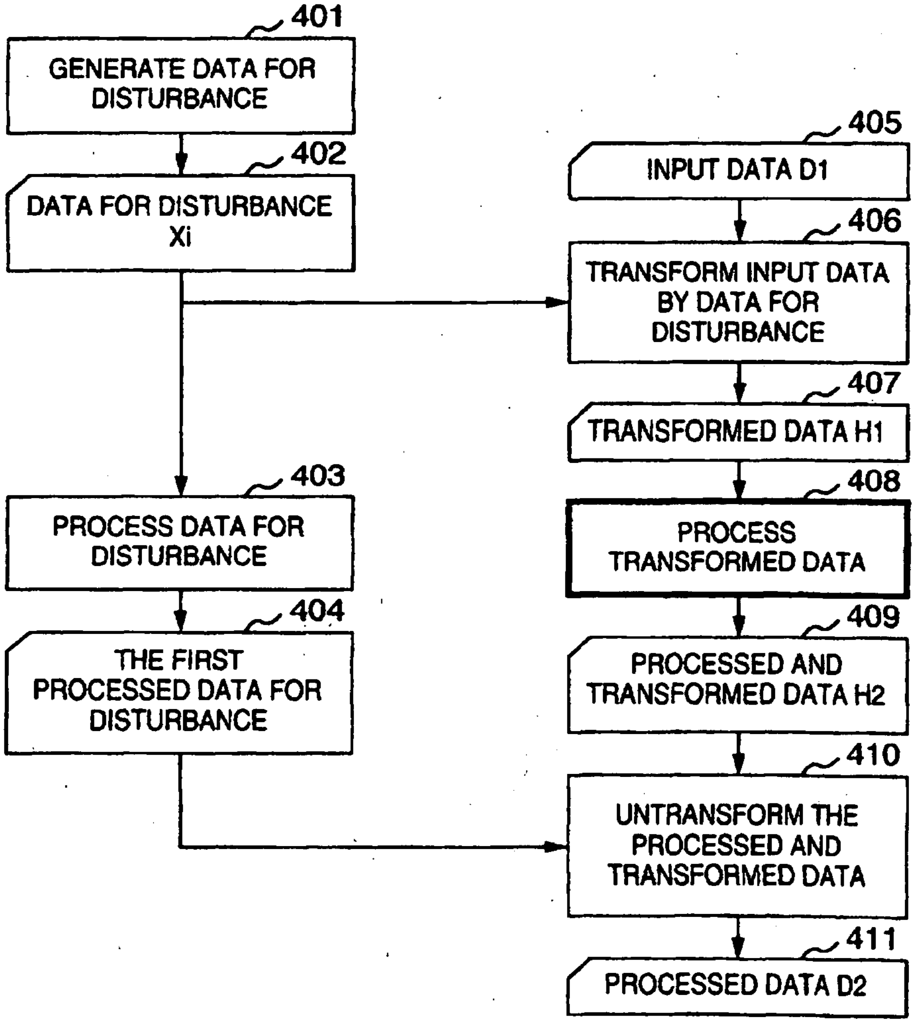

401
GENERATE DATA FOR DISTURBANCE
402
DATA FOR DISTURBANCE Xi
403
PROCESS DATA FOR DISTURBANCE
404
THE FIRST PROCESSED DATA FOR DISTURBANCE
405
INPUT DATA D1
406
TRANSFORM INPUT DATA BY DATA FOR DISTURBANCE
407
TRANSFORMED DATA H1
408
PROCESS TRANSFORMED DATA
409
PROCESSED AND TRANSFORMED DATA H2
410
UNTRANSFORM THE PROCESSED AND TRANSFORMED DATA
411
PROCESSED DATA D2

FIG. 5

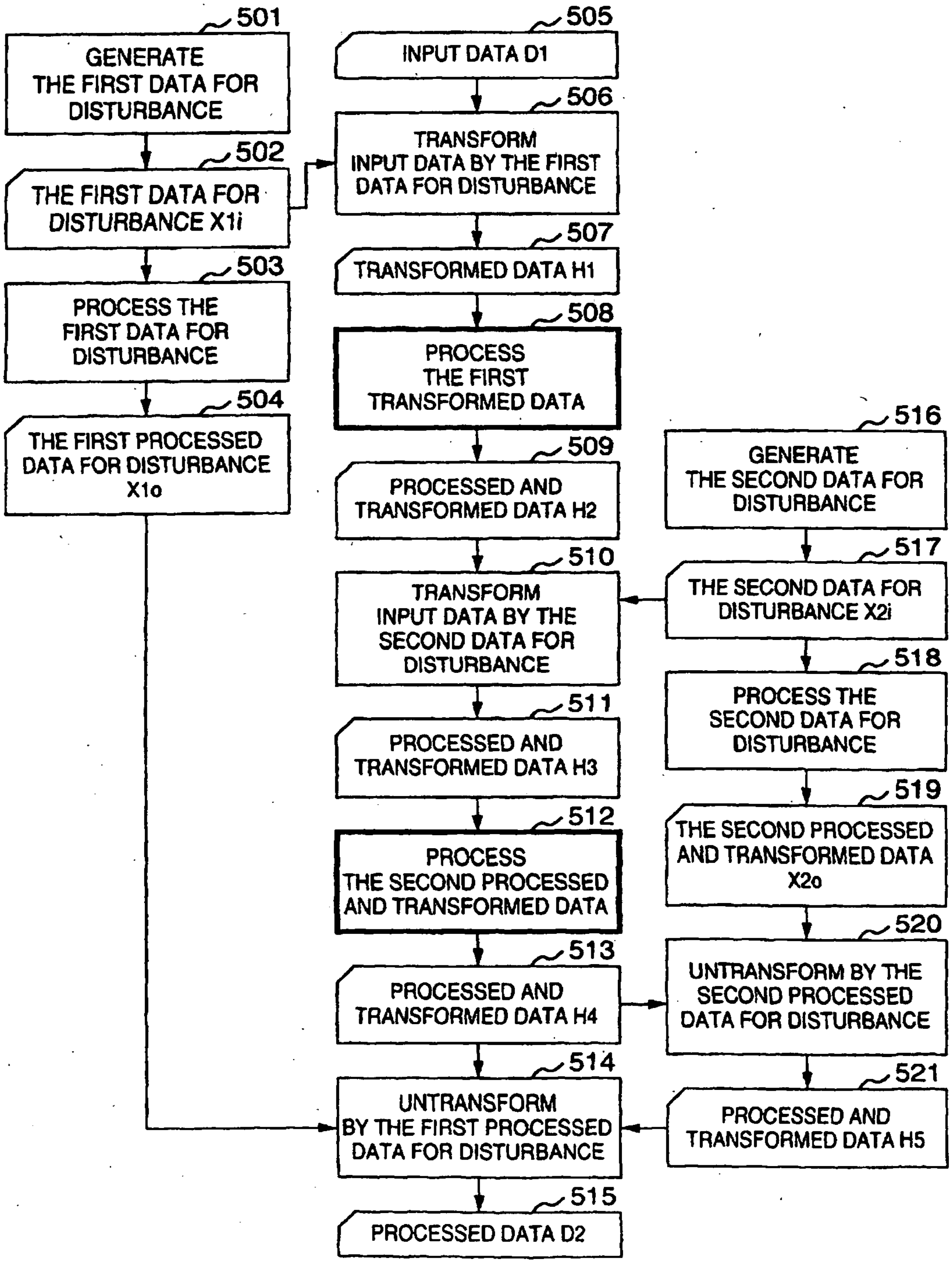

501
GENERATE THE FIRST DATA FOR DISTURBANCE
502
THE FIRST DATA FOR DISTURBANCE X1i
503
PROCESS THE FIRST DATA FOR DISTURBANCE
504
THE FIRST PROCESSED DATA FOR DISTURBANCE X1o
505
INPUT DATA D1
506
TRANSFORM INPUT DATA BY THE FIRST DATA FOR DISTURBANCE
507
TRANSFORMED DATA H1
508
PROCESS THE FIRST TRANSFORMED DATA
509
PROCESSED AND TRANSFORMED DATA H2
510
TRANSFORM INPUT DATA BY THE SECOND DATA FOR DISTURBANCE
511
PROCESSED AND TRANSFORMED DATA H3
512
PROCESS THE SECOND PROCESSED AND TRANSFORMED DATA
513
PROCESSED AND TRANSFORMED DATA H4
514
UNTRANSFORM BY THE FIRST PROCESSED DATA FOR DISTURBANCE
515
PROCESSED DATA D2
516
GENERATE THE SECOND DATA FOR DISTURBANCE
517
THE SECOND DATA FOR DISTURBANCE X2i
518
PROCESS THE SECOND DATA FOR DISTURBANCE
519
THE SECOND PROCESSED AND TRANSFORMED DATA X2o
520
UNTRANSFORM BY THE SECOND PROCESSED DATA FOR DISTURBANCE
521
PROCESSED AND TRANSFORMED DATA H5

FIG. 6

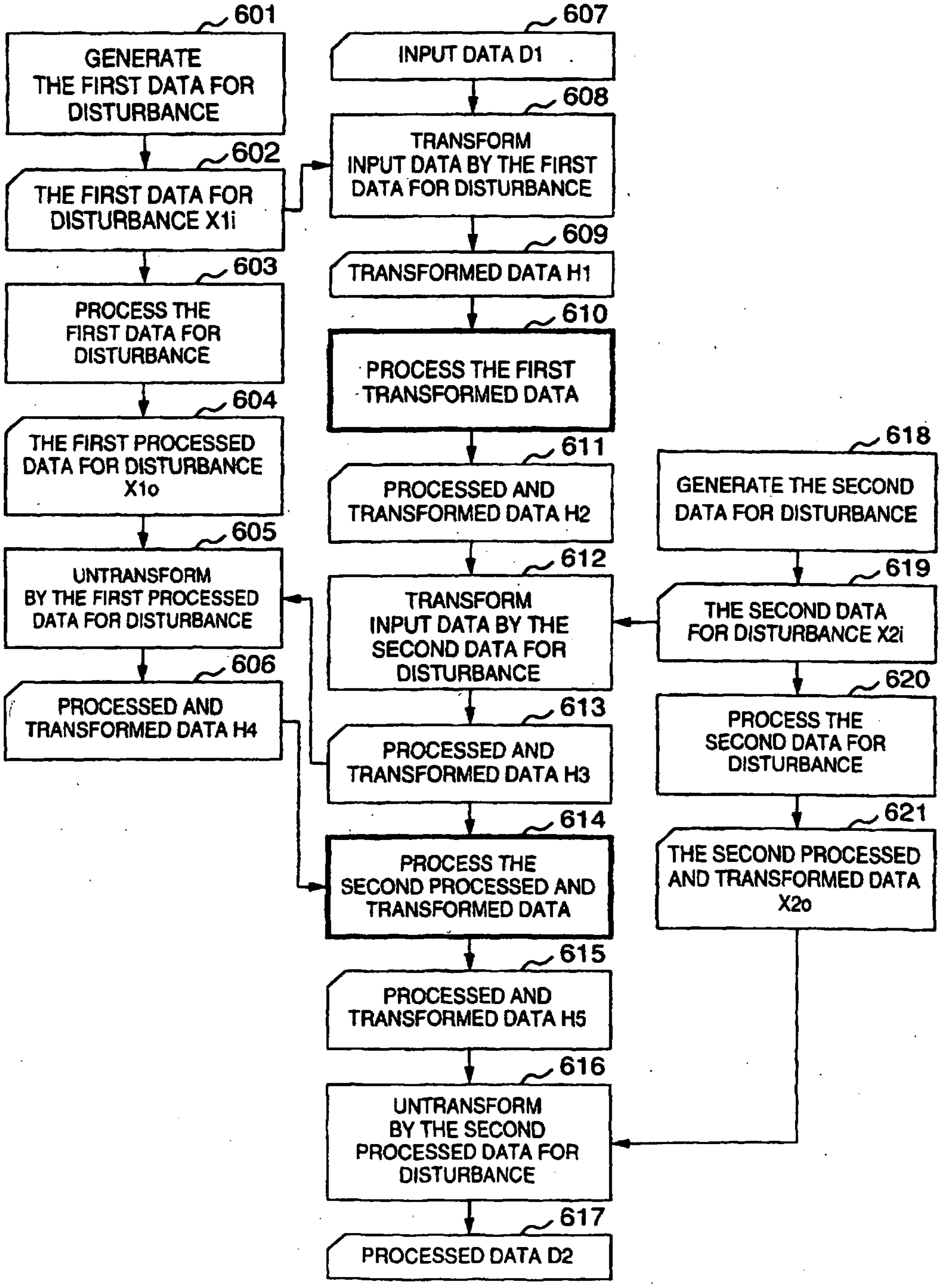

601
GENERATE THE FIRST DATA FOR DISTURBANCE
602
THE FIRST DATA FOR DISTURBANCE X1i
603
PROCESS THE FIRST DATA FOR DISTURBANCE
604
THE FIRST PROCESSED DATA FOR DISTURBANCE X1o
605
UNTRANSFORM BY THE FIRST PROCESSED DATA FOR DISTURBANCE
606
PROCESSED AND TRANSFORMED DATA H4
607
INPUT DATA D1
608
TRANSFORM INPUT DATA BY THE FIRST DATA FOR DISTURBANCE
609
TRANSFORMED DATA H1
610
PROCESS THE FIRST TRANSFORMED DATA
611
PROCESSED AND TRANSFORMED DATA H2
612
TRANSFORM INPUT DATA BY THE SECOND DATA FOR DISTURBANCE
613
PROCESSED AND TRANSFORMED DATA H3
614
PROCESS THE SECOND PROCESSED AND TRANSFORMED DATA
615
PROCESSED AND TRANSFORMED DATA H5
616
UNTRANSFORM BY THE SECOND PROCESSED DATA FOR DISTURBANCE
617
PROCESSED DATA D2
618
GENERATE THE SECOND DATA FOR DISTURBANCE
619
THE SECOND DATA FOR DISTURBANCE X2i
620
PROCESS THE SECOND DATA FOR DISTURBANCE
621
THE SECOND PROCESSED AND TRANSFORMED DATA X2o

FIG. 7

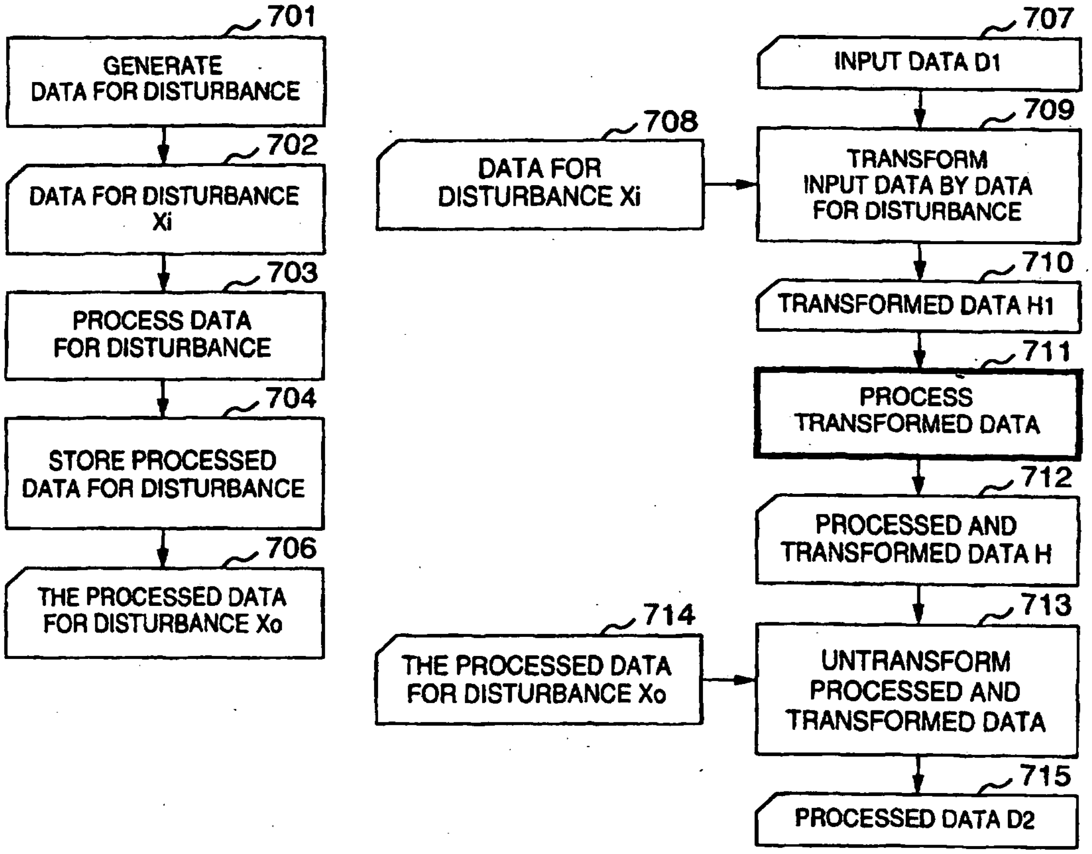

701
GENERATE DATA FOR DISTURBANCE
702
DATA FOR DISTURBANCE Xi
703
PROCESS DATA FOR DISTURBANCE
704
STORE PROCESSED DATA FOR DISTURBANCE
706
THE PROCESSED DATA FOR DISTURBANCE Xo
708
DATA FOR DISTURBANCE Xi
714
THE PROCESSED DATA FOR DISTURBANCE Xo
707
INPUT DATA D1
709
TRANSFORM INPUT DATA BY DATA FOR DISTURBANCE
710
TRANSFORMED DATA H1
711
PROCESS TRANSFORMED DATA
712
PROCESSED AND TRANSFORMED DATA H
713
UNTRANSFORM PROCESSED AND TRANSFORMED DATA
715
PROCESSED DATA D2

FIG. 8

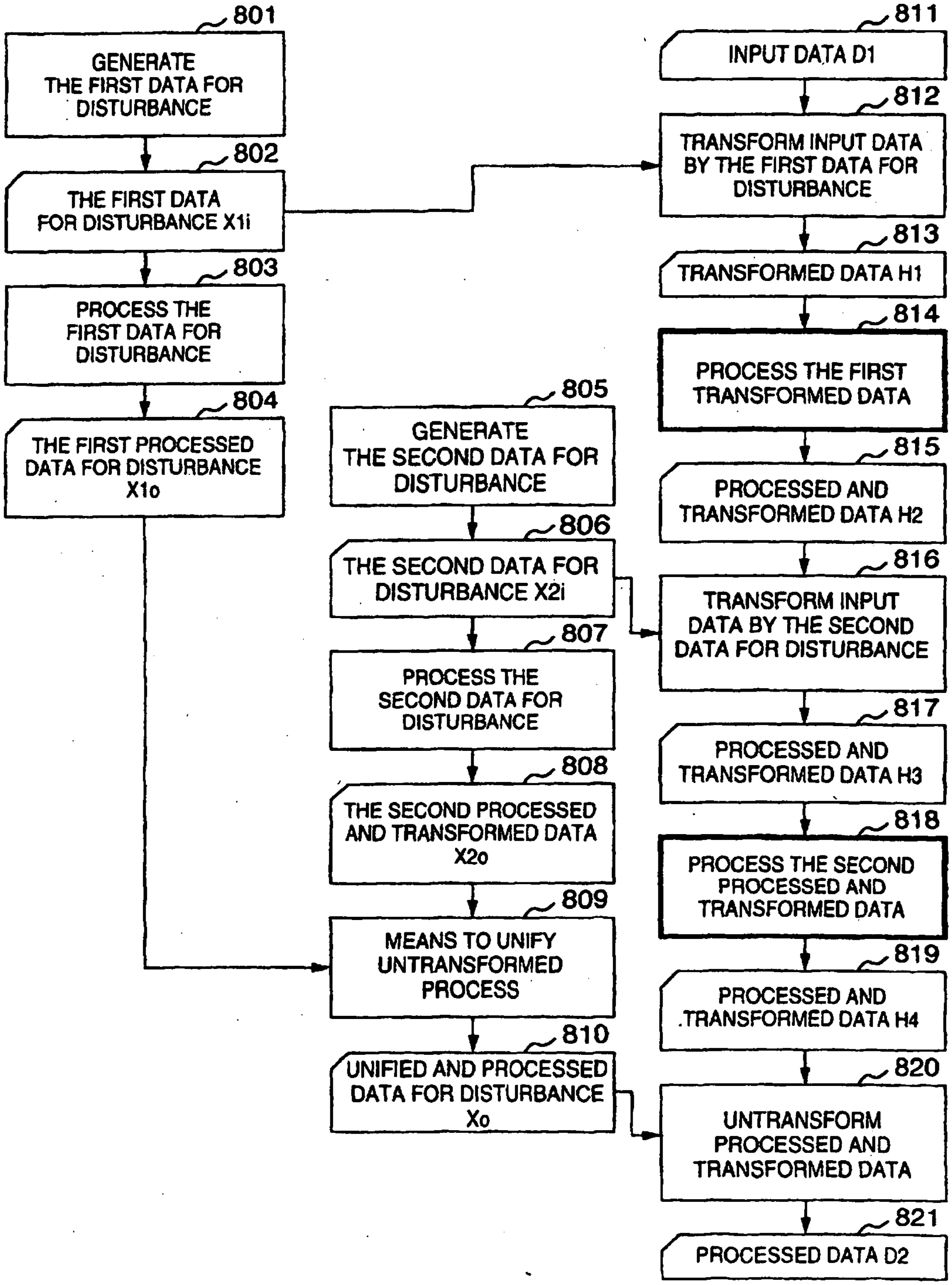

801
GENERATE THE FIRST DATA FOR DISTURBANCE
802
THE FIRST DATA FOR DISTURBANCE X1i
803
PROCESS THE FIRST DATA FOR DISTURBANCE
804
THE FIRST PROCESSED DATA FOR DISTURBANCE X1o
805
GENERATE THE SECOND DATA FOR DISTURBANCE
806
THE SECOND DATA FOR DISTURBANCE X2i
807
PROCESS THE SECOND DATA FOR DISTURBANCE
808
THE SECOND PROCESSED AND TRANSFORMED DATA X2o
809
MEANS TO UNIFY UNTRANSFORMED PROCESS
810
UNIFIED AND PROCESSED DATA FOR DISTURBANCE Xo
811
INPUT DATA D1
812
TRANSFORM INPUT DATA BY THE FIRST DATA FOR DISTURBANCE
813
TRANSFORMED DATA H1
814
PROCESS THE FIRST TRANSFORMED DATA
815
PROCESSED AND TRANSFORMED DATA H2
816
TRANSFORM INPUT DATA BY THE SECOND DATA FOR DISTURBANCE
817
PROCESSED AND TRANSFORMED DATA H3
818
PROCESS THE SECOND PROCESSED AND TRANSFORMED DATA
819
PROCESSED AND TRANSFORMED DATA H4
820
UNTRANSFORM PROCESSED AND TRANSFORMED DATA
821
PROCESSED DATA D2

FIG. 9

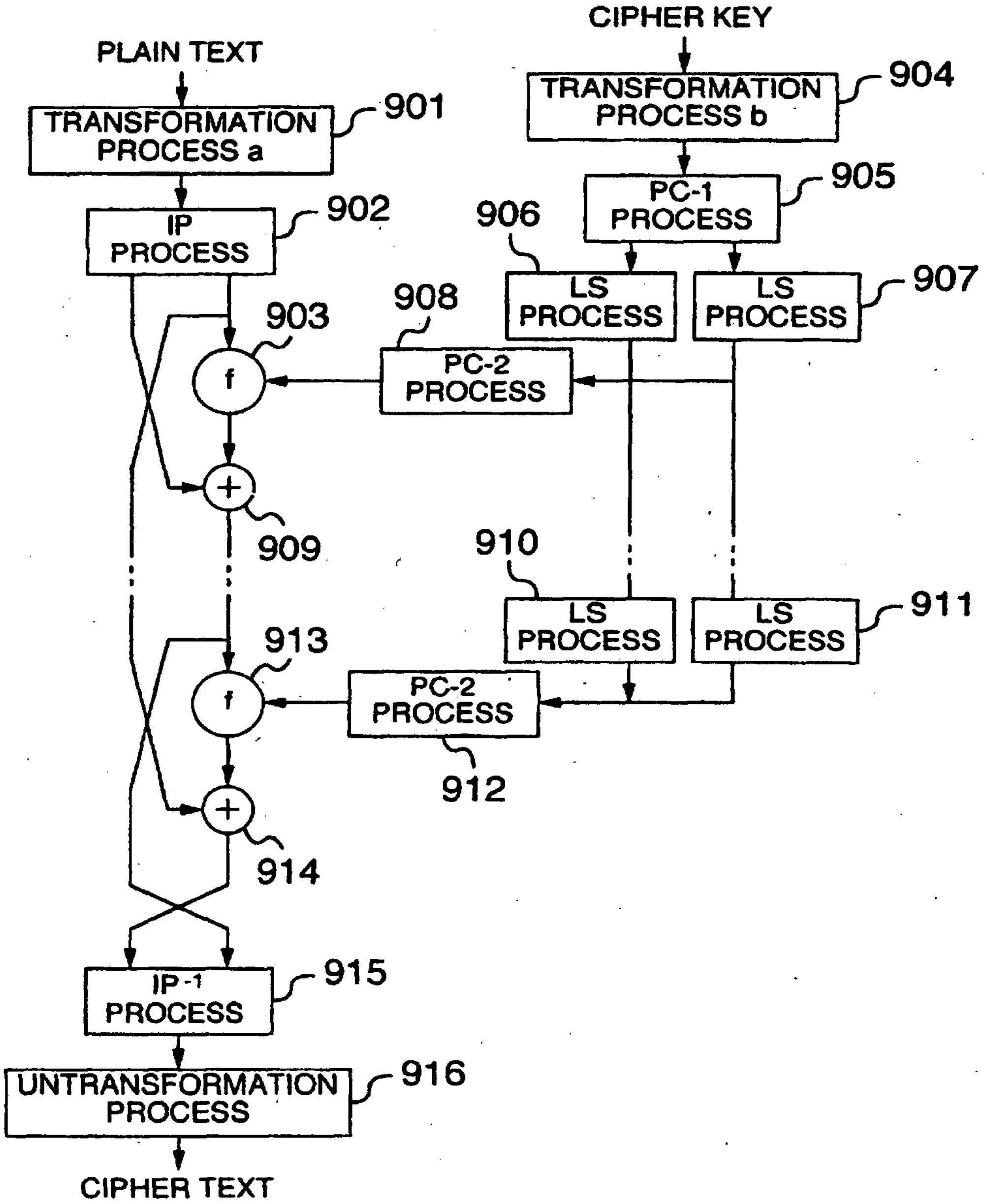

CIPHER KEY
PLAIN TEXT
TRANSFORMATION PROCESS b
904
TRANSFORMATION PROCESS a
901
PC-1 PROCESS
905
IP PROCESS
902
906
LS PROCESS
LS PROCESS
907
903
908
f
PC-2 PROCESS
909
910
LS PROCESS
LS PROCESS
911
913
f
PC-2 PROCESS
912
914
IP -1 PROCESS
915
UNTRANSFORMATION PROCESS
916
CIPHER TEXT

FIG. 10

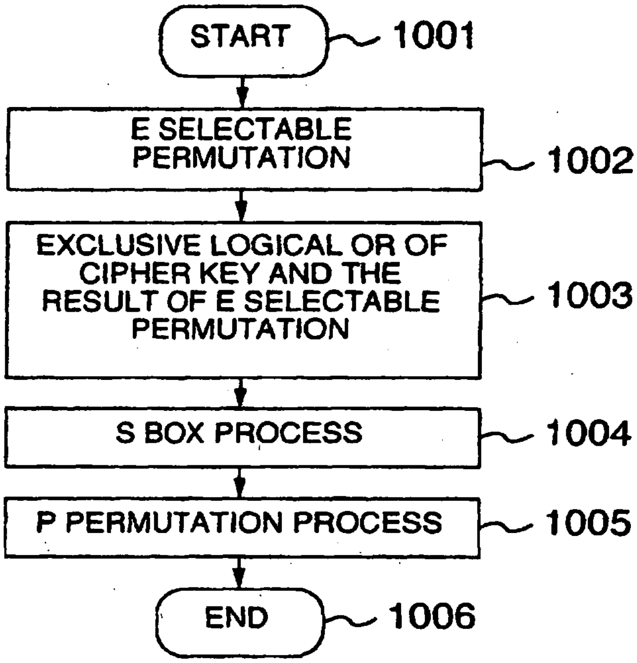

START
1001
E SELECTABLE PERMUTATION
1002
EXCLUSIVE LOGICAL OR OF CIPHER KEY AND THE RESULT OF E SELECTABLE PERMUTATION
1003
S BOX PROCESS
1004
P PERMUTATION PROCESS
1005
END
1006

FIG. 11

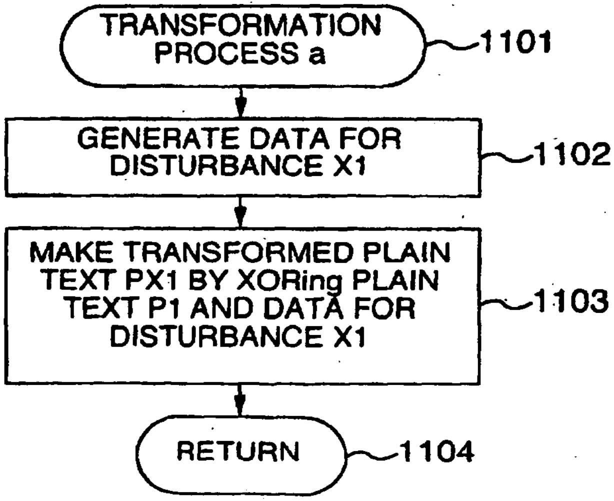

TRANSFORMATION PROCESS a
1101
GENERATE DATA FOR DISTURBANCE X1
1102
MAKE TRANSFORMED PLAIN TEXT PX1 BY XORing PLAIN TEXT P1 AND DATA FOR DISTURBANCE X1
1103
RETURN
1104

FIG. 12

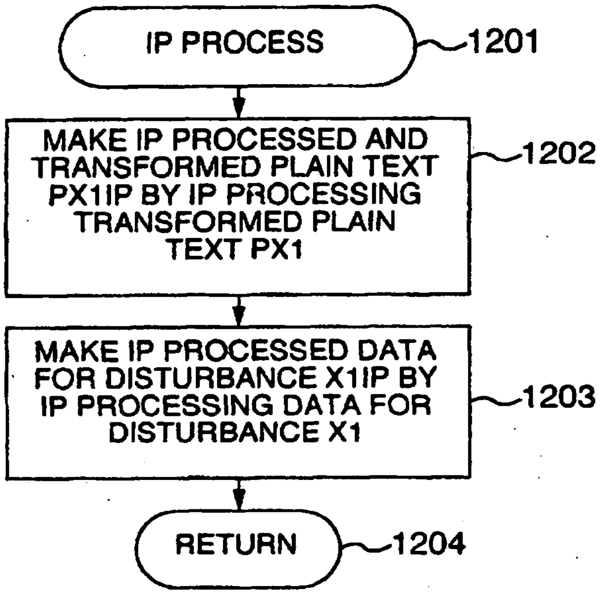

IP PROCESS
1201
MAKE IP PROCESSED AND TRANSFORMED PLAIN TEXT PX1IP BY IP PROCESSING TRANSFORMED PLAIN TEXT PX1
1202
MAKE IP PROCESSED DATA FOR DISTURBANCE X1IP BY IP PROCESSING DATA FOR DISTURBANCE X1
1203
RETURN
1204

FIG. 13

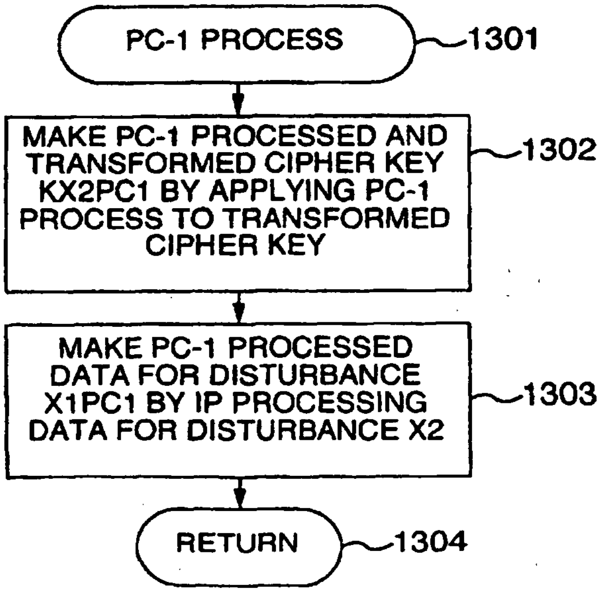

PC-1 PROCESS
1301
MAKE PC-1 PROCESSED AND TRANSFORMED CIPHER KEY KX2PC1 BY APPLYING PC-1 PROCESS TO TRANSFORMED CIPHER KEY
1302
MAKE PC-1 PROCESSED DATA FOR DISTURBANCE X1PC1 BY IP PROCESSING DATA FOR DISTURBANCE X2
1303
RETURN
1304

FIG. 14

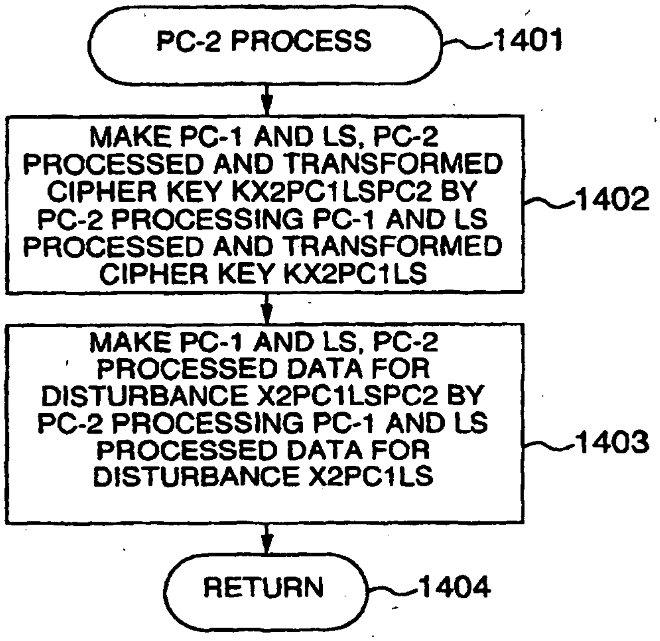

PC-2 PROCESS
1401
MAKE PC-1 AND LS, PC-2 PROCESSED AND TRANSFORMED CIPHER KEY KX2PC1LSPC2 BY PC-2 PROCESSING PC-1 AND LS PROCESSED AND TRANSFORMED CIPHER KEY KX2PC1LS
1402
MAKE PC-1 AND LS, PC-2 PROCESSED DATA FOR DISTURBANCE X2PC1LSPC2 BY PC-2 PROCESSING PC-1 AND LS PROCESSED DATA FOR DISTURBANCE X2PC1LS
1403
RETURN
1404

FIG. 15

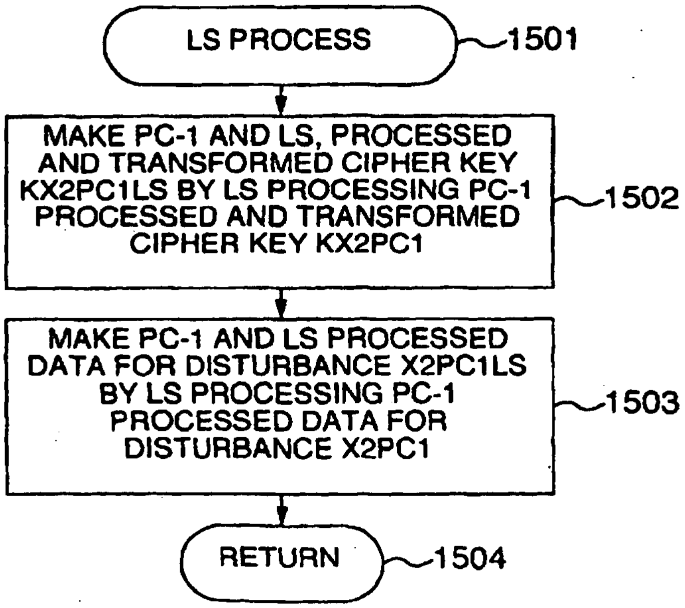

LS PROCESS
1501
MAKE PC-1 AND LS, PROCESSED AND TRANSFORMED CIPHER KEY KX2PC1LS BY LS PROCESSING PC-1 PROCESSED AND TRANSFORMED CIPHER KEY KX2PC1
1502
MAKE PC-1 AND LS PROCESSED DATA FOR DISTURBANCE X2PC1LS BY LS PROCESSING PC-1 PROCESSED DATA FOR DISTURBANCE X2PC1
1503
RETURN
1504

FIG. 16

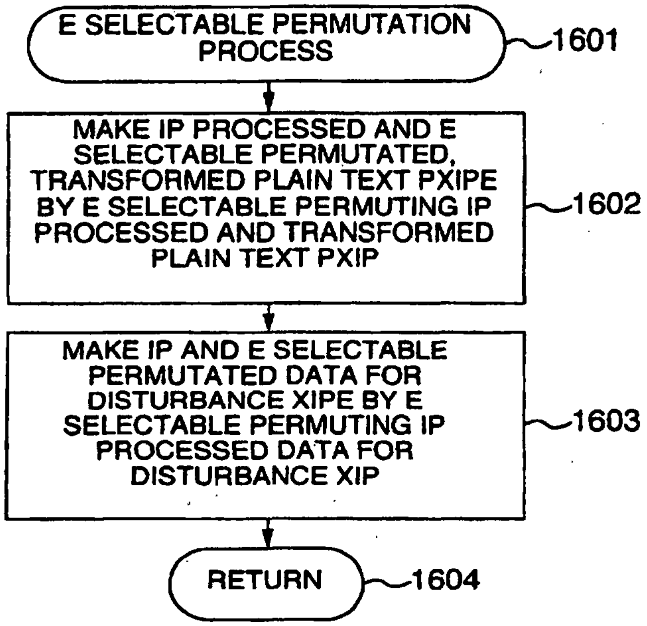

E SELECTABLE PERMUTATION PROCESS
1601
MAKE IP PROCESSED AND E SELECTABLE PERMUTATED, TRANSFORMED PLAIN TEXT PXIPE BY E SELECTABLE PERMUTING IP PROCESSED AND TRANSFORMED PLAIN TEXT PXIP
1602
MAKE IP AND E SELECTABLE PERMUTATED DATA FOR DISTURBANCE XIPE BY E SELECTABLE PERMUTING IP PROCESSED DATA FOR DISTURBANCE XIP
1603
RETURN
1604

FIG. 17

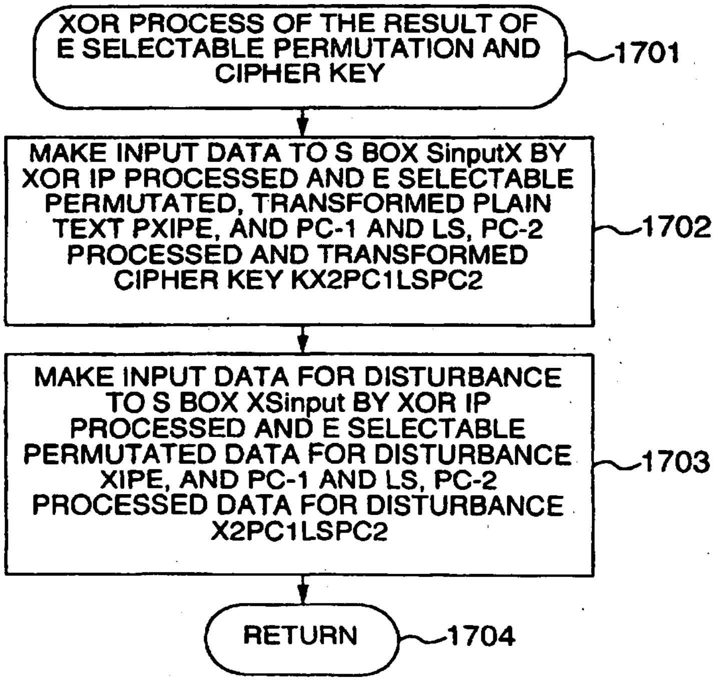

XOR PROCESS OF THE RESULT OF E SELECTABLE PERMUTATION AND CIPHER KEY
1701
MAKE INPUT DATA TO S BOX SinputX BY XOR IP PROCESSED AND E SELECTABLE PERMUTATED, TRANSFORMED PLAIN TEXT PXIPE, AND PC-1 AND LS, PC-2 PROCESSED AND TRANSFORMED CIPHER KEY KX2PC1LSPC2
1702
MAKE INPUT DATA FOR DISTURBANCE TO S BOX XSinput BY XOR IP PROCESSED AND E SELECTABLE PERMUTATED DATA FOR DISTURBANCE XIPE, AND PC-1 AND LS, PC-2 PROCESSED DATA FOR DISTURBANCE X2PC1LSPC2
1703
RETURN
1704

FIG. 18

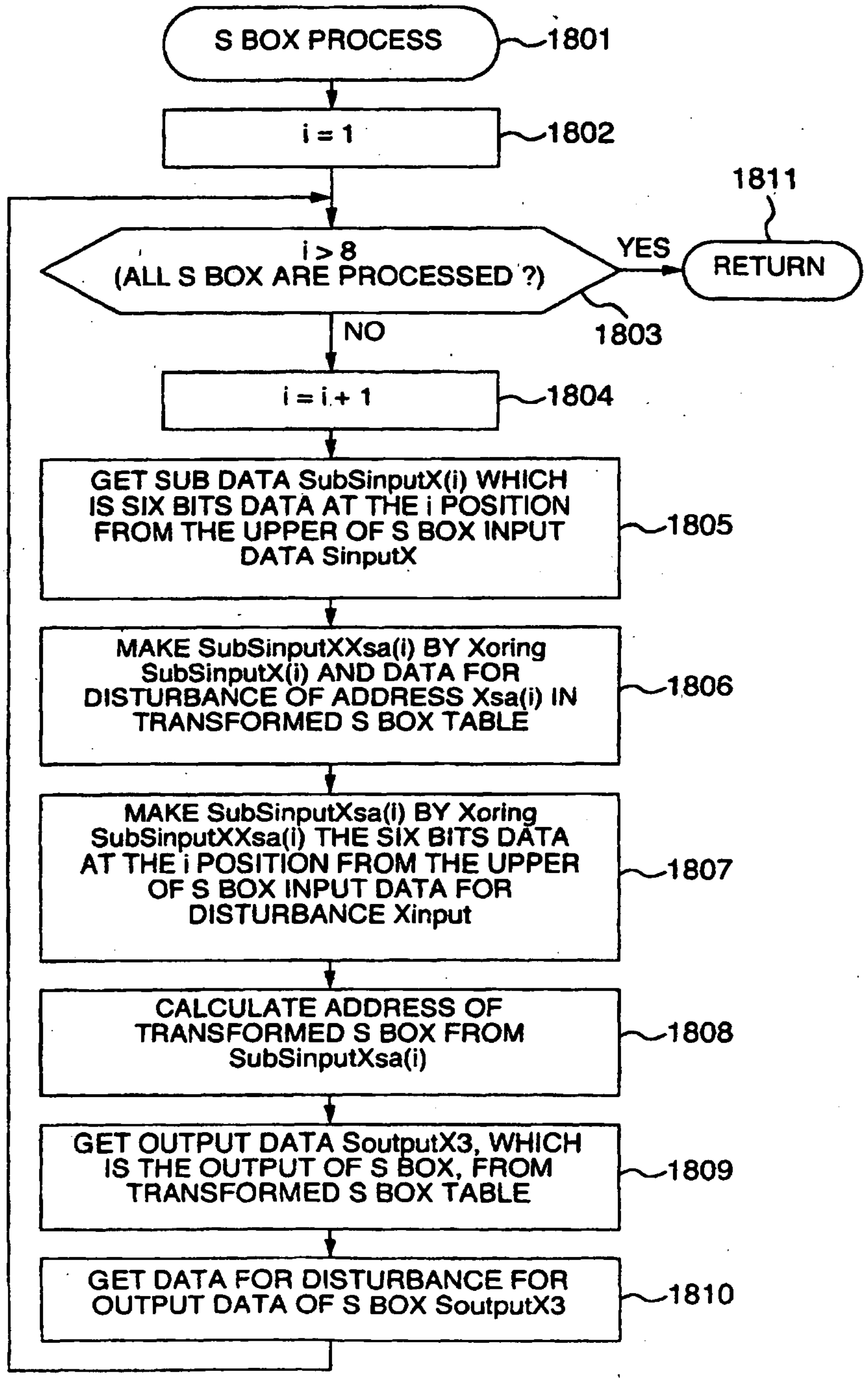

S BOX PROCESS
1801
i = 1
1802
1811
i > 8
(ALL S BOX ARE PROCESSED ?)
YES
RETURN
1803
NO
i = i + 1
1804
GET SUB DATA SubSinputX(i) WHICH IS SIX BITS DATA AT THE i POSITION FROM THE UPPER OF S BOX INPUT DATA SinputX
1805
MAKE SubSinputXXsa(i) BY Xoring SubSinputX(i) AND DATA FOR DISTURBANCE OF ADDRESS Xsa(i) IN TRANSFORMED S BOX TABLE
1806
MAKE SubSinputXsa(i) BY Xoring SubSinputXXsa(i) THE SIX BITS DATA AT THE i POSITION FROM THE UPPER OF S BOX INPUT DATA FOR DISTURBANCE Xinput
1807
CALCULATE ADDRESS OF TRANSFORMED S BOX FROM SubSinputXsa(i)
1808
GET OUTPUT DATA SoutputX3, WHICH IS THE OUTPUT OF S BOX, FROM TRANSFORMED S BOX TABLE
1809
GET DATA FOR DISTURBANCE FOR OUTPUT DATA OF S BOX SoutputX3
1810

FIG. 19

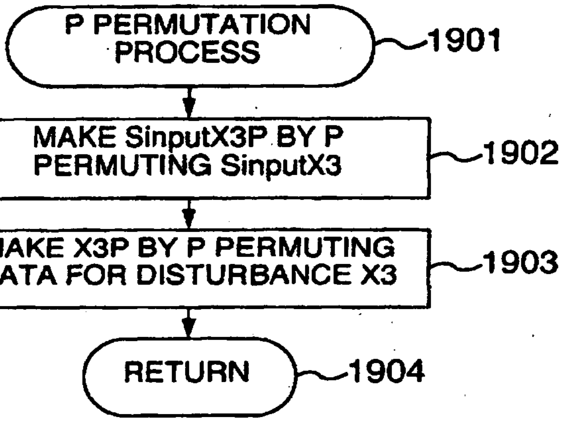

P PERMUTATION PROCESS
1901
MAKE SinputX3P BY P PERMUTING SinputX3
1902
MAKE X3P BY P PERMUTING DATA FOR DISTURBANCE X3
1903
RETURN
1904

FIG. 20

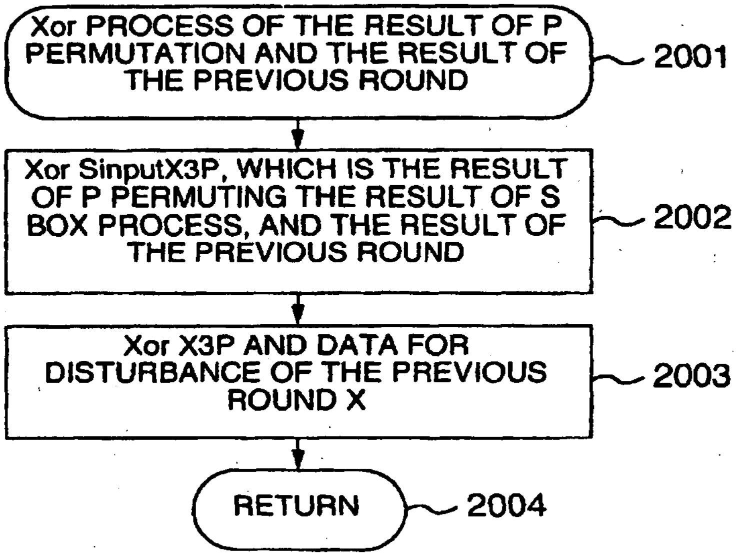

Xor PROCESS OF THE RESULT OF P PERMUTATION AND THE RESULT OF THE PREVIOUS ROUND
2001
Xor SinputX3P, WHICH IS THE RESULT OF P PERMUTING THE RESULT OF S BOX PROCESS, AND THE RESULT OF THE PREVIOUS ROUND
2002
Xor X3P AND DATA FOR DISTURBANCE OF THE PREVIOUS ROUND X
2003
RETURN
2004

FIG. 21

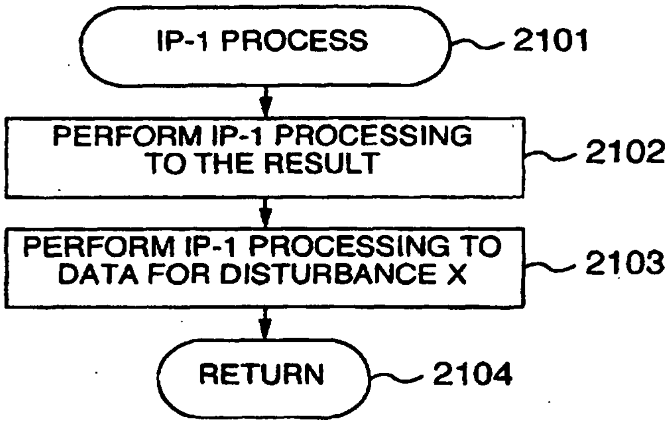

IP-1 PROCESS
2101
PERFORM IP-1 PROCESSING TO THE RESULT
2102
PERFORM IP-1 PROCESSING TO DATA FOR DISTURBANCE X
2103
RETURN
2104

FIG. 22

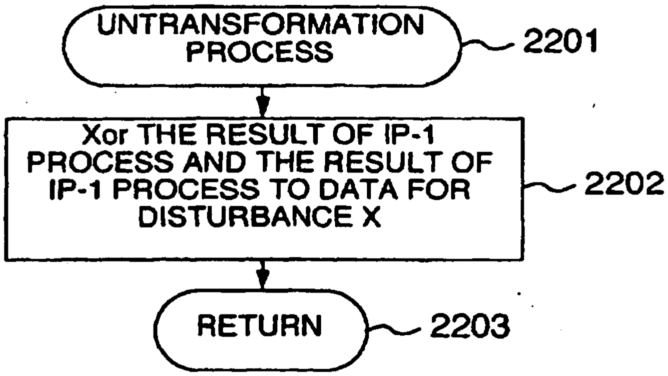

UNTRANSFORMATION PROCESS
2201
Xor THE RESULT OF IP-1 PROCESS AND THE RESULT OF IP-1 PROCESS TO DATA FOR DISTURBANCE X
2202
RETURN
2203

FIG. 23

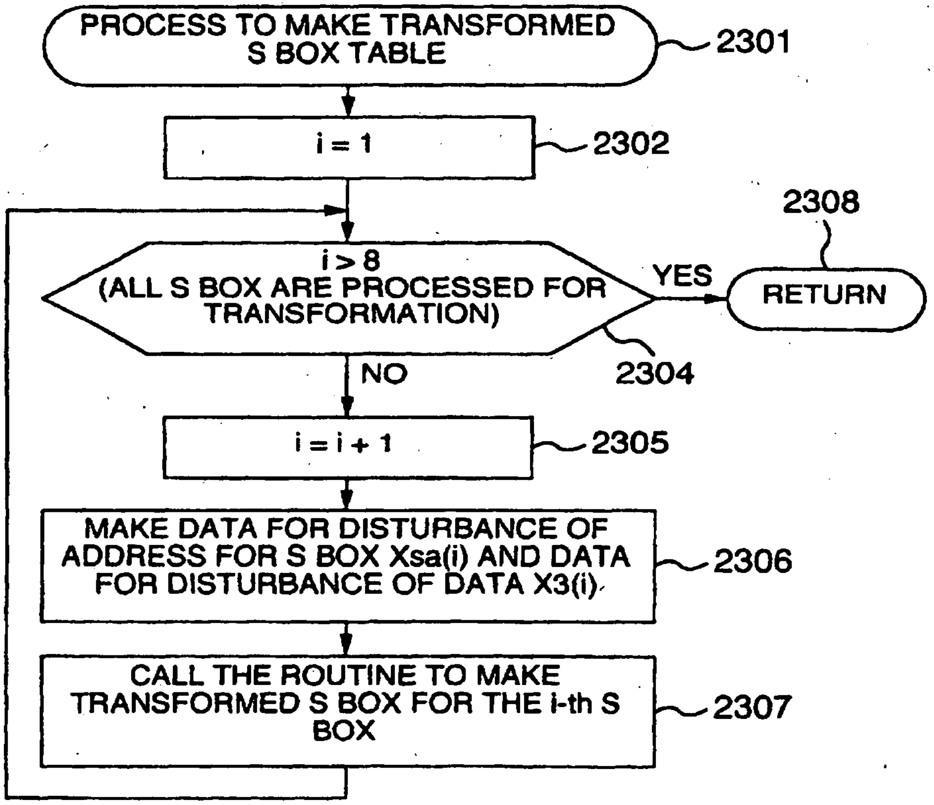

PROCESS TO MAKE TRANSFORMED S BOX TABLE
2301
i = 1
2302
2308
i > 8
(ALL S BOX ARE PROCESSED FOR TRANSFORMATION)
YES
RETURN
2304
NO
i = i + 1
2305
MAKE DATA FOR DISTURBANCE OF ADDRESS FOR S BOX Xsa(i) AND DATA FOR DISTURBANCE OF DATA X3(i)
2306
CALL THE ROUTINE TO MAKE TRANSFORMED S BOX FOR THE i-th S BOX
2307

FIG. 24

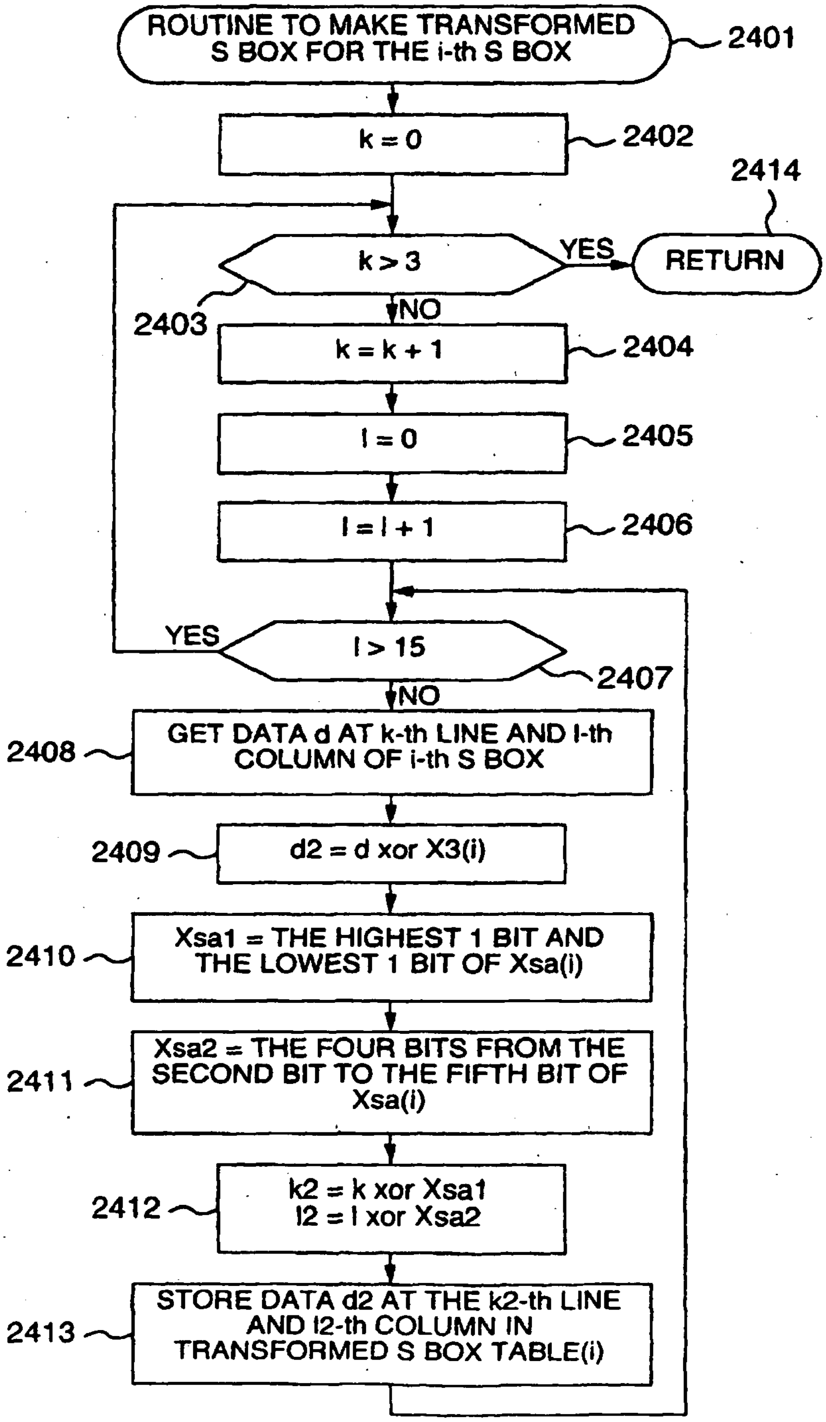
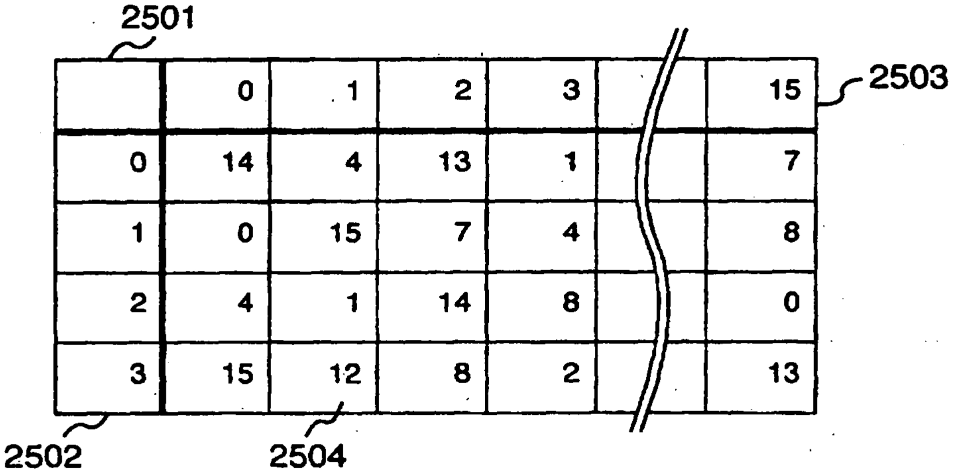

ROUTINE TO MAKE TRANSFORMED S BOX FOR THE i-th S BOX
2401
k = 0
2402
2414
k > 3
YES
RETURN
2403
NO
k = k + 1
2404
l = 0
2405
l = l + 1
2406
YES
l > 15
2407
NO
GET DATA d AT k-th LINE AND l-th COLUMN OF i-th S BOX
2408
d2 = d xor X3(i)
2409
Xsa1 = THE HIGHEST 1 BIT AND THE LOWEST 1 BIT OF Xsa(i)
2410
Xsa2 = THE FOUR BITS FROM THE SECOND BIT TO THE FIFTH BIT OF Xsa(i)
2411
k2 = k xor Xsa1
l2 = l xor Xsa2
2412
STORE DATA d2 AT THE k2-th LINE AND l2-th COLUMN IN TRANSFORMED S BOX TABLE(i)
2413

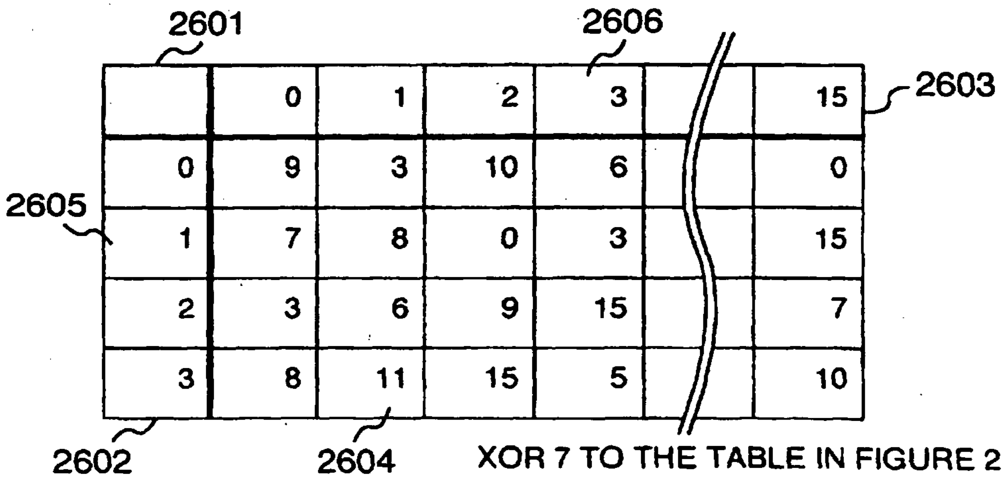
FIG. 25



	0	1	2	3		15
0	14	4	13	1		7
1	0	15	7	4		8
2	4	1	14	8		0
3	15	12	8	2		13

2501
2503
2502
2504

FIG. 26

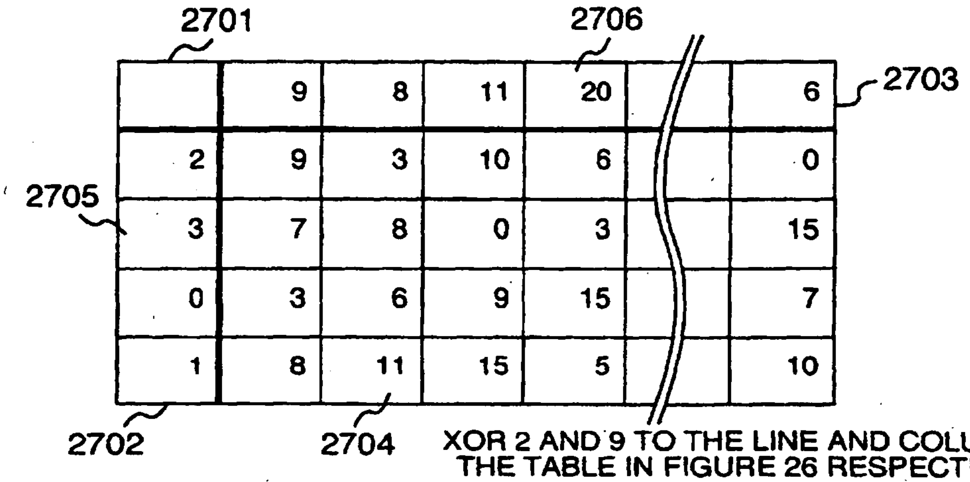


	0	1	2	3		15
0	9	3	10	6		0
1	7	8	0	3		15
2	3	6	9	15		7
3	8	11	15	5		10

2601
2606
2603
2605
2602
2604

XOR 7 TO THE TABLE IN FIGURE 25

FIG. 27


2701
2706
2703
2705
2702
2704

	9	8	11	20		6
2	9	3	10	6		0
3	7	8	0	3		15
0	3	6	9	15		7
1	8	11	15	5		10

XOR 2 AND 9 TO THE LINE AND COLUMN IN THE TABLE IN FIGURE 26 RESPECTIVELY

FIG. 28

	1	2	3	4	5	6
1	32	1	2	3	4	5
2	4	5	6	7	8	9
3	8	9	10	11	12	13
4	12	13	14	15	16	17
5	16	17	18	19	20	21
6	20	21	22	23	24	25
7	24	25	26	27	28	29
8	28	29	30	31	32	1

FIG. 29

16	7	20	21
29	12	28	17
1	15	23	26
5	18	31	10
2	8	21	14
32	27	3	9
19	13	30	6
22	11	4	25

2901

FIG. 30

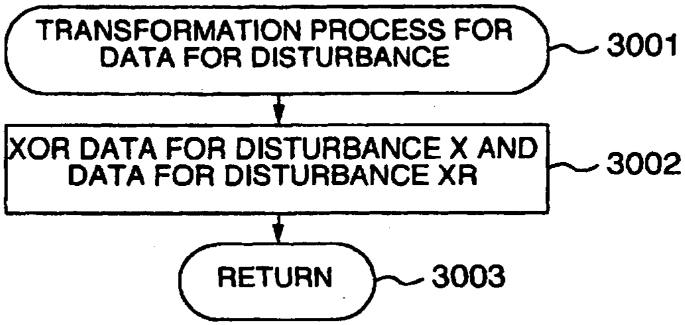

TRANSFORMATION PROCESS FOR DATA FOR DISTURBANCE
3001
XOR DATA FOR DISTURBANCE X AND DATA FOR DISTURBANCE XR
3002
RETURN
3003

FIG. 31

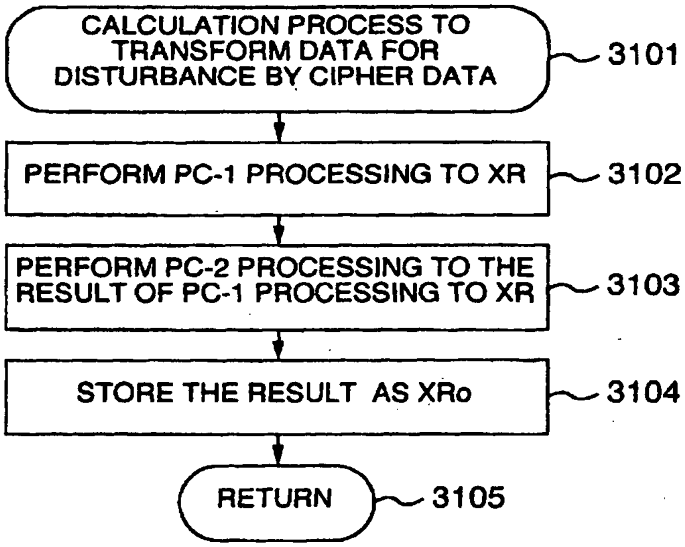

CALCULATION PROCESS TO TRANSFORM DATA FOR DISTURBANCE BY CIPHER DATA
3101
PERFORM PC-1 PROCESSING TO XR
3102
PERFORM PC-2 PROCESSING TO THE RESULT OF PC-1 PROCESSING TO XR
3103
STORE THE RESULT AS XRo
3104
RETURN
3105

FIG. 32

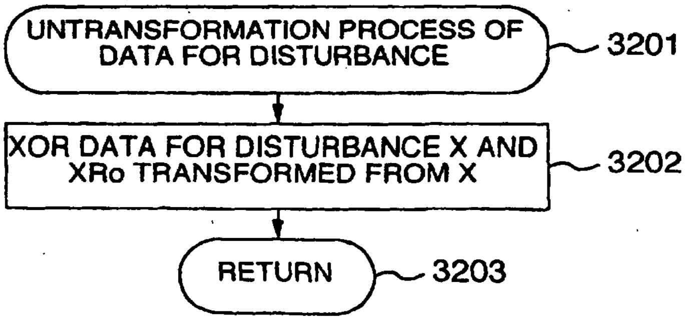

UNTRANSFORMATION PROCESS OF DATA FOR DISTURBANCE
3201
XOR DATA FOR DISTURBANCE X AND XRo TRANSFORMED FROM X
3202
RETURN
3203

FIG. 33

3301

	0	1	2	3
0	B	3	8	7
1	1	4	0	D
2	2	F	A	9
3	6	C	5	E

FIG. 34

3401

	0	1	2	3
0	2	A	1	E
1	8	D	9	4
2	B	6	3	0
3	F	5	C	7

FIG. 35

	0	1	2	3
0	5	F	7	C
1	6	B	0	3
2	D	8	4	9
3	A	2	E	1

3501

FIG. 36

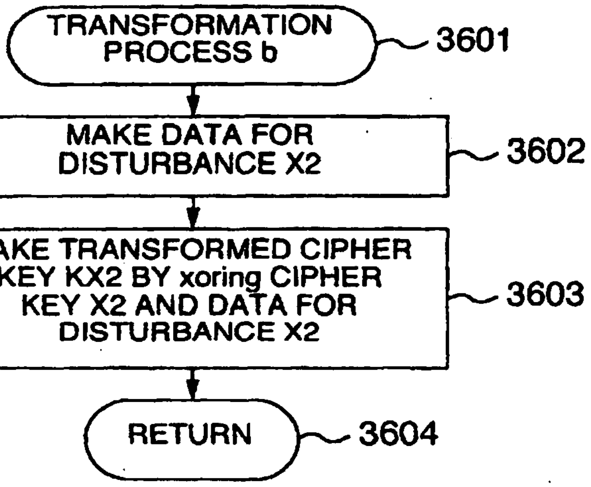

TRANSFORMATION PROCESS b
3601
MAKE DATA FOR DISTURBANCE X2
3602
MAKE TRANSFORMED CIPHER KEY KX2 BY xoring CIPHER KEY X2 AND DATA FOR DISTURBANCE X2
3603
RETURN
3604

FIG. 37

58	50	42	34	26	18	10	2
60	52	44	36	28	20	12	4
62	54	46	38	30	22	14	6
64	56	48	40	32	24	16	8
57	49	41	33	25	17	9	1
59	51	43	35	27	19	11	3
61	53	45	37	29	21	13	5
63	55	47	39	31	23	15	7

FIG. 38

57	49	41	33	25	17	9
1	58	50	42	34	26	18
10	2	59	51	43	35	27
19	11	3	60	52	44	36
63	55	47	39	31	23	15
7	62	54	46	38	30	22
14	6	61	53	45	37	29
21	13	5	28	20	12	4